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FOREWORD

During recent years there has been a growing realization amongst British farmers of the importance of ley farming in the agricultural economy of the country. The most ardent and expert advocate of this system is Sir George Stapledon who, by modern scientific methods of plant breeding and selection, has revolutionized the ancient practice of ley farming and demonstrated its great value in modern mixed farming practice. In the mixed farming areas of East Africa the need for leys to alternate with arable land is even greater than in Europe because of the more urgent necessity to devise effective means for conserving our soil and maintaining fertility by natural means rather than by importing manures. In an important article in this number Mr. Edwards reviews various aspects of ley farming in East Africa, describes the type of grass required and gives an account of a selected type of Rhodes grass which promises to be a valuable discovery. The early ley experiments in East Africa were carried out with imported grass species from temperate regions and, as might be expected, were unsuccessful. Mr. Edwards has rightly concentrated on the search for local grasses which would adapt themselves to ley culture. He lays no claim to have made a unique discovery and suggests that efforts should be made to discover other ecotypes adapted to our different climatic zones. There is good evidence that many such variants could be found, given the facilities. The need for such facilities is nowhere greater than in East Africa, where we hope to see proper financial provision made for pasture research after the war.

Mr. Culwick in his article on "The fundamental economics of export crops" packs a lot of provocation into a couple of pages. Some will think that he exaggerates. Those who do will find comfort in the commentaries by Mr. Liversage and Dr. Martin. It is all a question of balance: and obviously the factors involved will vary in their intensity and efficacy from place to place. We do not know at present how fast the minerals withdrawn by cropping are replaced from the sub-soil—under any of the multiplicity of East African conditions. (More work for soil scientists.) And it is to natural means of replacement we have to look until such time as all those who cultivate in Africa tend their soil as regularly and thoroughly as farmers in the best parts of Europe. It would be gross optimism to think of that stage as anything but remote. Mr. Liversage notes that "the great bulk of what we export is carbon, hydrogen, oxygen and nitrogen, all of which we can replace by natural means on the spot if we will". Well, do we "will", in the original, active and compulsive, sense of the word? And do we "will" consistently enough?

Mr. Brasnett's letter in this same number is, like Mr. Graham's recent articles, another symptom of the quickening insistence that we must think ahead: plan for the long future. Mr. Brasnett points out that the African population is drawing heavily on timber reserves for fuel. It is living on capital. The further the process goes the more difficult and the more unsatisfactory from the point of view of orthodox economics it is going to be to get a necessary working balance together again.

Special attention is drawn to the useful practical articles by Mr. Fane and Mr. Weller on a method of canalization and on building with lime.

CORRIGENDA AND ADDENDUM

1. The author of the review (this Journal, Vol. 9, p. 59) on Mr. Edwards' article on grass-burning (*Emp. Jnl. Exper. Agric.*, Oct. 1942, pp. 219–231) writes to say that owing to an error in copying, lines 4–7, second column, p. 59, should read "in an experiment in the Southern Highlands of Tanganyika, laid down in 1931, Red Oat Grass has largely disappeared from the unburnt plots", not "burnt plots" as originally printed.

For the information of those interested he adds that the "ten years study in the U.S.A.", from which he quotes the conclusion "soil organic matter is maintained at a higher level in grasslands frequently burnt over", is that of W. G. Wahlenborg, S. W. Greene and H. R. Reed (*U.S. Dept. Agric., Tech. Bull.* No. 683, 1939).

2. Vol. 9 (1), July 1943, p. 48, first column; the sentence on lines 1–4 should read: "undoubtedly a very large proportion of the present gazetted forests could be converted into farms", not "should be converted".

THE NZOIA TYPE OF RHODES GRASS (CHLORIS GAYANA)* FOR TEMPORARY LEYS

By D. C. Edwards, Senior Agricultural Officer (Pasture Research), Kenya

Since the start of pasture research in Kenya some years ago, one of the important lines of work has been directed towards the discovery of plants for the artificial establishment of pasture where it is desired to convert arable land to grass. This practice is possible throughout the moister parts of the country, in all areas where the annual rainfall is roughly 30 inches or above.

The idea of ley-farming, in which temporary grass of three to six years' duration is used in rotation with arable crops as a means of maintaining soil fertility and inducing the recovery of partially exhausted land, has gained ground in European districts in recent years. In thickly populated native areas it has become an imperative necessity to introduce intensive soil-conserving methods of farming, and in this development the fertility-building capacity of the ley must eventually form the corner-stone of future agricultural policy.

Under the high temperatures and erratic rainfall of Kenya, the crumb structure of the soil rapidly deteriorates in arable cultivation. The resultant reduction in capacity to absorb and retain moisture and in the stability of the surface-soil under the influence of water and wind quickly shows itself in a reduction of crop yields. Hence it is of extreme importance to introduce into the farming systems, both European and native, a means by which desirable soil structure can be economically restored and grazing animals concentrated in order to accumulate organic manure. The pasture ley provides this means to a marked degree.

The earliest attempts to sow down pasture in East Africa were made by farmers in the highland areas, using temperate grass species, in the superiority of which they naturally believed. As may be expected, such attempts to utilize plants developed under entirely different climatic conditions met with very little success. Work on this subject has therefore been mainly concentrated upon an investigation of the natural flora, in the hope of obtaining from it pasture plants suited to the requirements of ley establishment.

The main characteristics which are required of a grass for this purpose under local conditions are (*a*) ability to form a complete cover rapidly, (*b*) at least moderate persistence under heavy grazing (*c*) ease of eradication when it becomes necessary to change the land back to arable crops, and (*d*) availability of planting material in the form of a commercial seed supply.

Early in the work stoloniferous or creeping grasses, which are widely distributed in Kenya and characteristic of many parts of the country, showed, with few exceptions, considerable promise in the rapid production of a cover and in resistance to heavy grazing. Further, those which do not possess rhizomes in addition to surface-creeping stems present little difficulty in cleaning the land for cultivation. Comparatively few of the indigenous grasses, however, were found to produce viable seed in sufficient quantity to allow of establishment by sowing. When an adequate seed supply is available, establishment is frequently uncertain on account of marked dry periods which often occur after sowing, even when the rains are deemed to have set in. In this connexion, the stoloniferous species have a distinct advantage, in that although only partial germination may have been attained, by virtue of their creeping habit they are capable of producing a complete cover when moisture increases.

It soon became evident that no artificially established pasture could be regarded as "permanent". In fact, most of the grasses rapidly fell in productiveness under cultivation, and an obvious requirement was to discover species capable of even moderate persistence under intensive management. Early observations, later confirmed in practice, clearly showed, however, that established pasture for the first year or two of its life was markedly more productive than old natural grassland.

Since it was necessary at the outset to test a considerable number of grasses, which were known to be of value in natural pasture or which had (in two cases) been recommended from countries of somewhat similar climate, a means of comparison which did not involve actual grazing trials had to be devised. This consisted of a randomized block of small plots (10 ft. × 10 ft.) embracing eighteen grasses, each replicated four times. The plots were cut short on the same date each month and all the material removed. At the same time, the herbage from a yard quadrat in the centre of each plot was taken for yield determinations

* Apart from incidental references, Rhodes Grass was the subject of an article in this *Journal*, Vol. I, p. 233.

and for separation into weeds and grass. It is not claimed that this plan is exactly equivalent to trial under grazing conditions, but it is maintained that grasses which are capable of withstanding successfully such severe treatment would be unlikely to fail under intensive management, and the method affords a means of comparison.

The main result from this initial experiment was that in a period of a little over a year most of the species became greatly reduced by the treatment and several to a large extent died out.

Following this work, the six species, which appeared most promising, were included in a further similar experiment. These were *Chloris gayana* (from Queensland), *C. gayana* (Kabete type), *Cenchrus ciliaris* (low-growing type), *Cynodon plectostachyum* (Star grass), *Bothriochloa insculpta*, and *Pennisetum clandestinum* (Kikuyu grass). To these were added the Nzoïa type of *Chloris gayana* and the Giant *Cynodon* sp. (Giant Star grass), making a total of eight grasses.

As the result of elevated masses of land, marked contrasts in climate are a striking feature of Kenya, and under such conditions it is not surprising that plant species which are, in many cases, widely distributed have, through a process of adaptation, produced localized ecotypes or naturally occurring strains. This fact gives much scope for the investigation of types within the species. Several such ecotypes of Rhodes grass (*Chloris gayana*) have been obtained, three of which were included in the above experiment.

TABLE I—PERCENTAGE GROUND COVER OF ALL GRASSES IN JUNE, 1942, AFTER SIX YEARS OF SEVERE TTREATMENT, DETERMINED BY THE POINT QUADRAT METHOD (1)

SPECIES	Block	Cover of species	*Burn of species	*P. clandestinum*	*Chloris pycnothrix*	*Digitaria abyssinica*	*Eragrostis tenuifolia*	Other grasses	Weeds not grass	*Trifolium johnstonii*	Burn, not of sown sp.	Bare ground
Chloris gayana (Nzoia) ..	I	76	24	—	—	—	—	—	—	—	—	—
	II	79	18	2	—	—	—	—	—	—	—	1
	III	82	13	—	4	—	—	—	—	—	—	1
	IV	82	15	—	—	—	—	—	2	—	—	1
C. gayana (Kabete) ..	I	52	15	—	19	3	2	3	—	—	5	1
	II	50	12	—	24	2	—	9	—	—	2	1
	III	66	24	—	4	1	—	2	2	—	—	1
	IV	68	13	—	11	—	—	7	—	—	1	—
C. gayana (Queensland)..	I	18	1	22	49	5	1	1	—	—	3	—
	II	18	1	36	26	3	—	—	1	13	1	1
	III	29	14	—	18	16	5	2	4	—	6	6
	IV	35	12	—	20	12	10	4	2	—	4	1
Cynodon plectostachyum ..	I	3	—	—	17	9	15	45	2	—	9	—
	II	7	—	13	37	28	1	8	—	—	6	—
	III	4	1	31	22	13	15	4	1	—	9	—
	IV	7	—	—	41	22	3	11	2	—	13	1
Bothriochloa insculpta ..	I	—	—	56	1	—	39	1	—	1	2	—
	II	8	—	13	56	8	4	5	2	—	4	—
	III	3	—	35	24	18	14	1	—	—	5	—
	IV	24	3	1	27	33	7	1	—	—	4	—
Pennisetum clandestinum	I	98	1	—	—	—	—	—	1	—	—	—
	II	84	1	—	—	—	—	—	2	13	—	—
	III	89	5	—	4	2	—	—	—	—	—	—
	IV	96	3	—	—	—	—	—	—	—	—	1
Giant *Cynodon* sp. ..	I	3	—	4	42	10	23	2	3	4	8	1
	II	3	—	7	47	16	1	17	—	6	3	—
	III	3	—	53	5	7	14	—	12	—	6	—
	IV	7	—	5	77	4	5	—	—	1	1	—
Cenchrus ciliaris ..	I	18	—	3	33	12	26	—	4	—	4	—
	II	13	—	9	51	6	3	3	3	11	1	—
	III	26	—	5	28	5	1	2	5	27	1	—
	IV	29	—	—	67	2	—	—	—	—	2	—

Differences between three types of *Chloris gayana* significant even at 0·001 level of probability.
*"Burn"=Old, dead material.

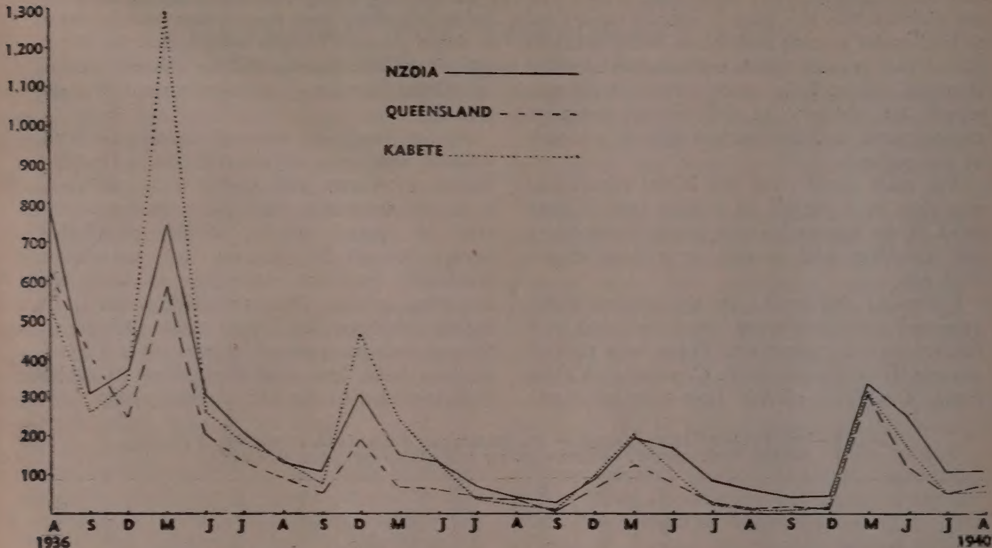

FIG. 1—Three ecotypes of *Chloris gayana*; air-dry yields of grass in grams from 4 yard quadrats; August, 1936, to August, 1940.

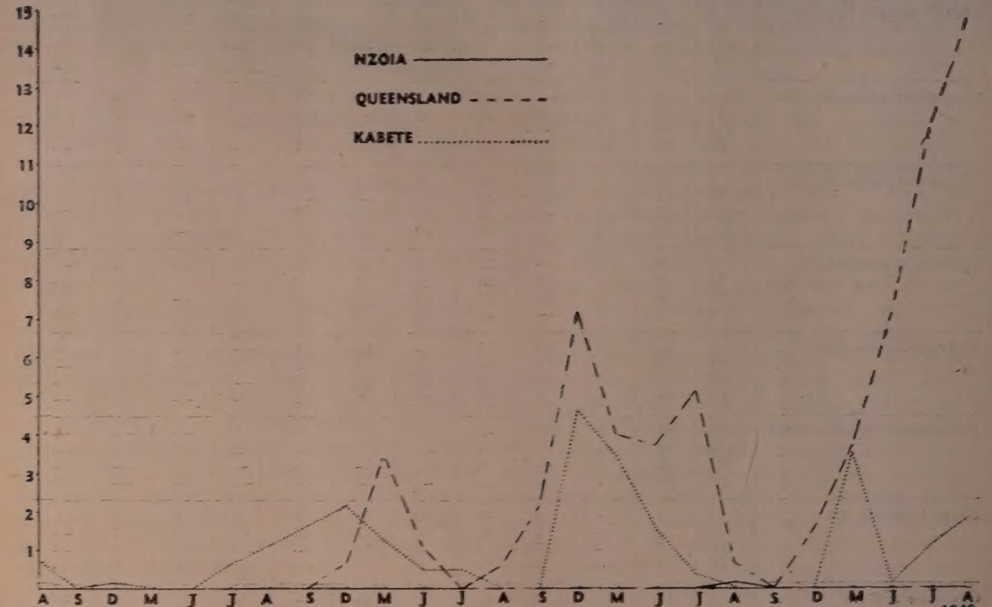

FIG. 2—Three ecotypes of *Chloris gayana*; showing weeds as percentage of air-dry material August, 1936, to August, 1940

Weeds = *Coryza schimperi, Digitaria abyssinica, Chloris pycnothrix, Bothriochloa insculpta, Trifolium johnstonii, Eragrostis tenuifolia, Rhynchelytrum roseum, Pennisetum clandestinum.*

Nzoia Rhodes grass at Kabete. Second hay crop in one year.

Nzoia Rhodes grass, ready for threshing seed crop.

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TABLE II—MILK YIELDS IN LB. DERIVED FROM PLOTS OF FOUR SPECIES OF GRASS

Grass	Plots Nos.	Cows Nos.	Yield of milk 10 days before experiment	Yield of milk 1st 10 days on experiment	Gain or loss	Cows Nos.	Yield of milk 2nd 10 days on experiment	Gain or loss on 1st 10 days of experiment
Nzoia *C. gayana*	3 and 7	1,247	144·7	154·5	+72·8	2,115	55·4	—12·1
		686	115·5	142·2		1,730	49·5	
		8,980	96·4	112·5		7,351	116·9	
		1,718	85·9	106·1		284	149·5	
B. insculpta	4 and 8	3,202	140·1	163·5	+56·8	9,577	143·5	—58·4
		6,577	104·1	114·9		4,225	146·3	
		2,486	101·9	109·8		5,492	50·0	
		1,727	87·5	102·2		6,622	57·3	
B. dictyoneura	1 and 5	9,577	177·1	190·2	+18·4	3,202	154·4	—59·9
		4,225	145·9	158·0		6,577	85·2	
		5,492	53·2	56·8		2,486	97·4	
		6,622	60·9	50·5		1,727	93·4	
Giant *Cynodon* sp. ..	2 and 6	2,115	59·7	46·0	—13·5	1,247	126·6	—113·5
		1,730	60·5	55·9		686	131·9	
		7,351	114·8	123·7		8,980	49·5	
		284	161·9	157·8		1,718	93·8	

One of the most promising grasses in the early work was Rhodes grass from Australia. The type originated in Africa, and in recent years has been developed and fairly extensively used in Queensland. Advantage was taken of the existence of a commercial seed supply to make extensive trials of this grass, and it proved successful over a wide area of the potential mixed farming country, up to an elevation of about 7,000 feet. It was found, however, that the type was of a distinctly temporary nature, and particularly in the drier districts, rapidly fell in productiveness. It appeared that leys of about two years' duration were all that could be expected of it.

The second plot experiment was established in November, 1935; the cutting treatment was started in August, 1936, and has been continued until the present time. By February, 1938, it became evident that the three ecotypes of Rhodes grass together with Kikuyu grass had so far withstood the treatment best, that *Cenchrus ciliaris* occupied an intermediate position and that the other three species were showing distinct signs of opening up and letting in weeds. In November, 1939, observations showed that only the Kabete and Nzoia ecotypes of Rhodes grass and the Kikuyu grass had maintained a sward in which weeds were unimportant. The Giant *Cynodon* sp. was at this date in a very degenerate condition and rapidly dying out. At the present time the same three grasses, indicated as successful by the foregoing observations, are the only types which remain moderately pure, and the object of this paper is to present the evidence upon which the Nzoia ecotype of Rhodes grass has been chosen as the most suitable for use in ley establishment over the greater part of Kenya in which mixed farming is practicable.

INFLUENCE OF THE NZOIA STRAIN OF RHODES GRASS UPON MILK YIELD

Results of a grazing experiment in which the Nzoia type of Rhodes grass was compared with three other grasses are given as evidence of the favourable influence which this grass is capable of exerting upon milk yield, and also as some indication of palatability. The experiment was set up in the April rains of 1938, before the foregoing results were fully available.

The grasses, which were *Brachiaria dictyoneura*, Giant *Cynodon* species, Nzoia type of *Chloris gayana* and *Bothriochloa insculpta*, were established in 1/3 acre strips, the series being duplicated to give a row of eight parallel plots, fenced individually.

Hay cuts were taken until the November rains of 1941, when the grazing test was carried out. Sixteen cows were used (two to each plot), and they were matched according to the point reached in the lactation. All cows had calved about the previous August. The group of four cows allotted to each grass was matched with other groups on the basis of milk yield from the ten days preceding the experiment. The animals were confined to the plots throughout the experiment, except when they were removed for milking at 7 a.m. and 2 p.m. each day. Water was provided in the experimental area.

After ten days on the plots the Rhodes grass group, which had then given the highest yield of milk, was changed with the Giant *Cynodon* group which had given the lowest yield, and the *B. dictyoneura* and *B. insculpta* groups were also interchanged. At this point one afternoon milking was discarded from the records on acount of possible disturbance caused by the change-over.

The cows were removed from good natural Kikuyu grass pasture to the experiment on 24th November and retained on the plots until 16th December.

The results are given in Table II.

Discussion

Table I, which gives the ground cover after six years, clearly shows that the Nzoia Rhodes grass persisted under severe treatment much better than the other grasses tested, with the exception of *Pennisetum clandestinum* (Kikuyu grass). The work was carried out at Kabete, which is situated at 6,200 feet altitude and has an annual rainfall of approximately 40 inches. These conditions are just within the natural habitat of Kikuyu grass, which is the dominant of the surrounding grassland and which could be expected to succeed. It will be seen from the table that this grass is one of the main "weeds" which tend to replace the species unable to withstand the treatment. This grass is, however, strictly limited by its climatic requirements and, in addition, has the disadvantage for use in leys of possessing a system of strong rhizomes. It can, therefore, be ruled out for the purpose in view, at least over the main crop-producing portion of the country in which temperatures are too high and moisture frequently too low for Kikuyu grass.

The three curves given in Fig. I show no very clear difference in the behaviour of the three ecotypes of Rhodes grass, although the yield of the commercial or Queensland type tends to be lower than the other two throughout. This graph does, however, indicate the tendency of the yields to decline as the ley becomes older. This has been noted for all species observed. It will be seen that the highest yields were obtained in the two rainy seasons following establishment of the grasses, although it should be mentioned that the rainfall was also above average in 1937.

Both this graph and Fig. II are based upon the figures obtained for the months of May to September (inclusive) and December in each year. The remaining six months are not included as the extremely low yields which can be expected would be of doubtful significance.

Fig. II requires little explanation. It shows the proportion of weeds in the samples taken from the three Rhodes grass types over the same four-year period. The marked inferiority of the Queensland strain in this respect is outstanding. Although it was free from weeds for the first year of the severe treatment, the rapid rise in the proportion of weeds from this point is a clear reflection of its poor persistence in comparison with the other two types. In the Nzoia Rhodes grass, the only appearance of weeds beyond a trace is seen in the August, 1939, sample.

Table II suggests that of the four grasses compared in the grazing experiment, the Nzoia Rhodes grass has the most satisfactory influence upon the milk yield of dairy cows. It will be observed that mid-way through this experiment the cows from the two plots of Giant Star grass which had given the poorest yield were changed over to the Rhodes grass plots, and although all groups showed a reduction of yield in the second half of the experiment compared with the first half, this reduction is significantly less in the case of Nzoia Rhodes grass. It should be mentioned that the poor results obtained from the Giant Star grass appeared to be definitely connected with a low degree of palatability.

With a view to obtaining evidence upon the aggregate and seasonal yields of nutrients offered by the eight grasses of the randomized-block experiment described above, samples were retained throughout for chemical analysis. Facilities to undertake this work are not yet available, but it is held that such evidence is not important to the present discussion. Experience indicates that a series of grasses under identical conditions of climate and soil exhibits comparatively small differences in chemical constitution, as long as the grasses are permitted to grow uncontrolled. Their respective reactions to grazing, and through these their yields of nutrients, are, however, widely different. Assuming moderate palatability, it is thus ability to persist under conditions of frequent defoliation which is of paramount importance in practice.

Apart from the importance of persistence from a nutritional view-point, the degree to which the ley is capable of excluding weeds has an important bearing on the expense involved in the cultivation of the following arable crops. Pasture which has become infested with

weeds will result in dirty land for subsequent cultivation. This is particularly true of Kenya, where weeds, such as *Digitaria abyssinica,* with deep underground stems are characteristic of degenerate pasture (see Table I). Farmers are well aware of the difficulty of eradicating this weed, which is locally known by its Kikuyu name of "Thangari". The aim in ley management should be a complete cover of the pasture with the soil well occupied by the roots. This condition is remarkably well attained by Rhodes grass, and reference to the results in regard to cover and exclusion of weeds will show that the statement is particularly true of the Nzoia type.

Rhodes grass is widely distributed in Kenya under a variety of climatic conditions. It can, therefore, be expected to be widely adaptable under cultivation. Trials have, in fact, shown that the grass can be successfully used over a range of conditions, varying roughly from 4,000 to 7,000 feet elevation with a minimum annual rainfall in the neighbourhood of 30 inches, thus embracing the major portion of both European and native agricultural areas. There is little doubt that the particular ecotype of the grass under discussion will prove at least as adaptable as the commercial variety with which the regional trials were made.

As a point of interest it may be mentioned that the name "Rhodes grass" is derived from the fact that this grass was first brought to notice by Cecil Rhodes, and from material cultivated by him near Capetown, the Australian type originated, which provides the present commercial supply of seed. It is suggested, however, that this grass has spread in the course of time from the hotter parts of Africa and has, in the process, doubtless become adapted to a variety of conditions. If this is correct, it can be expected to be more successful in the territories near to the equator, if full use can be made of the local ecotypes. The necessity of search for a frost-resistant strain of the grass in South Africa appears to support this view.

The natural home of Nzoia Rhodes grass is in one of the most important agricultural areas of Kenya to the west of the Nzoia River, where the altitudes vary from 5,000 to 6,000 feet and the annual rainfall is from 35 to 45 inches. It is confidently expected that this superior local strain will fulfil the main requirements of ley establishment over practically the whole of the crop-producing areas of the country, where moisture conditions are sufficiently good to permit of intensive methods of farming, with the exception of areas above 7,000 feet elevation and possibly of the low-lying coastal regions.

In enumerating the characteristics desirable in a grass for ley farming, the possibility of providing a commercial seed supply was mentioned. Several grasses which it is necessary to plant from roots and cuttings have been suggested for this purpose from time to time. Such methods obviously add considerably to the expense involved, apart from the difficulty of obtaining material which would be frequently experienced. The view is, therefore, held, that for a pasture plant to become an important factor in development in this direction, a commercial seed supply must be made available. This step has already been taken in the case of Nzoia Rhodes grass and seed may be bought cheaply in Kenya.

A further important consideration in ley-farming is the possibility of overlapping the last arable crop of a series with the grass ley, and so economizing in the cultural operations required and avoiding unnecessary exposure of the soil, by producing a pasture which will be ready for grazing a few months after the removal of the crop. It has been shown that Nzoia Rhodes grass, amongst others, can be successfully established under maize, the most widely cultivated crop in both native and European agriculture [2]. Further, no significant reduction in the yield of maize was recorded under the conditions of the experiment.

The foregoing discussion has dealt with the grass side of ley-farming, but in Kenya, as in more developed countries, there is ample evidence that the best results for both soil fertility and animal nutrition are obtainable from a mixed grass and legume pasture rather than from one composed entirely of grasses. Trials of many indigenous legumes have been made, so far with indifferent results, but lucerne in mixture with Rhodes grass has given considerable promise over a number of years. It is, therefore, recommended that the Nzoia strain of this grass should be sown at the rate of 10 to 15 lb. with 2 lb. of lucerne per acre.

Finally, a point regarding the management of the ley should be mentioned. Rhodes grass spreads by means of surface runners and will rapidly cover the ground in a favourable season. Early grazing should, however, be

avoided as there is a tendency at first for the animals to pull up the lightly rooted creeping stems. For this reason, and also with a view to producing an even stand of the grass from the frequently uneven initial growth, it is advisable to take a hay crop before grazing is started. The density of the sward, and to some extent its persistence, in subsequent years will depend largely upon the management of the ley. Careful grazing management produces a sward less prone to early infestation by weeds than the more open growth which results from frequent hay crops and little grazing.

ACKNOWLEDGMENTS

It is desired to acknowledge the work of the late Mr. T. K. Hill, who, as a student of the Veterinary Laboratory, maintained the records of the plot experiment during my absence on overseas leave in 1937, and of Mr. A. J. Wiley, who assisted later in the work.

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PRESERVATION OF HIDES AND SKINS

Throughout the East African territories the annual spoilage of hides and skins through decomposition is considerable. In the drier pastoral areas there is often unavoidable delay due to distance in getting skins to a hide-drying *banda*, and many fallen hides also are ruined owing to decomposition proceeding in the *banda* until such time as the hide becomes too dry. In some of the hot, humid areas it is indeed almost impossible at certain seasons to dry even abattoir hides without their sustaining damage.

As a result of experiments carried out by Dr. Reverberi at the Veterinary Research Laboratory, Kabete, the following treatment has been shown to arrest putrefaction without affecting the subsequent tanning procedures.

The hides are placed as soon as possible in a 0.5 per cent solution of either sodium fluoride or sodium nitrite and are left to soak overnight. They are then allowed to drain and are dried in the usual way.

Hides treated in this way may be turned into leather or, in the case of game skins, may be treated by the usual methods so as to leave on the coat. In the latter case hair-slip is prevented. Both sodium nitrite and sodium fluoride solutions of this strength are of low toxicity compared with arsenic and corrosive sublimate, and there should be little risk in their use by natives.

MEAD

Alcohol in its milder forms is traditionally associated with agricultural processes. Vying with the grape in antiquity, honey had long been a favoured source of the social lubricant until ousted by the synthetic brews and distillation products of the Mechanical Age. A mixture of honey and water allowed to ferment was called by the Greeks "hudromeli", by the Romans "hydromel" (as it is still known in France) or "aqua mulsa", by the ancient Britons "metheglin", and by the Saxons "mede", or as we know it to-day mead. There must have been something to it for the habit to persist so long. Beekeepers in Europe still make small quantities, but it is no longer so widely drunk as in the past.

To make mead, use four pounds of honey and the skin of two lemons to each gallon of water. Boil for half an hour and then strain through a coarse cloth. Allow to cool and then put into your jar or barrel with a dessertspoonful of dried yeast or the equivalent in yeast-cake for each gallon. Fermentation will last 12 to 15 days, after which time the vessel should be tightly sealed. During fermentation an air trap is desirable to allow the carbon dioxide to escape and to prevent air and the wrong kinds of yeasts from entering. This is made by having a piece of glass tubing passing through a hole in the cork and bending in an inverted U into a small bottle of water. The end of the tube is kept below the level of the water in the small bottle and a second hole in the cork of this bottle allows the gas to bubble out. The mead can be bottled at any time after fermentation is completed, but it is desirable to allow it to settle for a month. Mead should not be drunk for six months unless the need is great. If less than four pounds of honey is used, the mead is weak and to quote Pliny, "good for the sick, for those liable to catch cold, and for small-minded people". More than this amount does not increase the alcohol content but leaves the mead sweet and cloying. The better the flavour of the honey the better the mead, so do not use bitter honey from rubber areas.

FUNDAMENTAL ECONOMICS OF EXPORT CROPS

By A. T. Culwick, M.B.E., M.A., Tanganyika Territory

The Industrial Revolution is familiar to all of us, but how many of us have ever stopped to think out the implications of the astonishing agricultural revolution which has accompanied it? Let us look back a moment.

Trade in agricultural products, like trade in manufactured goods, is no creation of the last century and a half. Both have existed through history. It is their scale and the conditions under which they are carried on which have been revolutionized beyond all recognition. But while the social and economic consequences of the Industrial Revolution are inescapably obvious all round us, the true nature of the Agricultural Revolution seems to have remained hidden behind the different problems it has raised, which have appeared as separate though often inter-connected difficulties instead of being recognized as different manifestations of one basic problem.

As a result we tinker—can we really call it more?—with our problems of soil erosion, dust bowls, floods, droughts, diminishing fertility, wasteful and shifting cultivation, without thinking out the fundamental principles of the process in which we are engaged. Baldly, what we have built up is an elaborate system for exporting fertility from the tropics and dumping it into the sea via the sewers of great cities.

The great industrial populations of the earth clamour for foodstuffs to use and finally dispose of in their cities. The farmers of the civilized world, constantly feeding the precious fertility of their land to the cities in the form of dairy products, meat and vegetable foods, clamour for feeding materials and plant nutrients from distant lands. The manufacturers of the industrialized world clamour for the raw materials and the crops of tropical and other farming countries, to transform them into products of which only a minute proportion eventually returns to the countries, and so to the soils that produced them. At the producing end, the governments of agricultural communities dream of annually soaring export figures accompanied by corresponding imports of manufactured goods (most of which unfortunately do not greatly help the hungry land), abundant revenue and a prosperous and contented community. Scientific methods of farming and that noble animal the cow will, it is held, look after the land.

But there is an unfortunate, and it may well prove tragic, oversight in all this. We cannot escape the law of the conservation of matter. With all our science and with all our cows we can only transform, transport, redistribute, conserve plant nutrients—we cannot create them. If we export them faster than nature can replace them, we must either import them from somewhere else or reap a harvest of failure. Our proudly quoted export figures, besides being a measure of our income, also represent a loss to the soil which must be made good from somewhere before we can justifiably start talking about our profits.

We read, for instance, of a thousand tons of paddy rice being sold in some market at fifteen cents a kilo, and we probably think of this transaction solely in terms of the £7,500 which the fortunate growers receive. We usually forget that there has been exported from the cultivators' land some twelve tons of nitrogen, six hundred and sixty pounds of calcium oxide, the same quantity of potash, thirteen hundred pounds of sodium oxide, two tons of phosphorus, seven hundred and fifty pounds of chlorine, thirty tons of iron, quantities of sulphur, magnesium, iodine and traces of certain other substances.*

Fortunately a number of important plant nutrients—carbon, oxygen and hydrogen—are available in the atmosphere, so that given rain and air our supplies of these elements are inexhaustible. The same is true of nitrogen, provided conditions are such as to allow of its fixation by means of leguminous plants, but when we come to the other essential soil constituents, the minerals, we find a very different state of affairs. These substances are derived

* Compare the figures recently given by Harvey (*E. Afr. Med. J.*, 20 (7), 224, July, 1943). From Kenya "in 1939 roughly 50,000 tons of maize were exported and if we take its contents of these elements to be 1.47 per cent, 0.271 per cent and 0.314 respectively, then the amounts which were lost were 735 tons of nitrogen, 135.5 tons of phosphorus and 157 tons potassium. If we express these in terms of the three fertilizers, sulphate of ammonia, super-phosphate with 25 per cent soluble calcium hydrogen phosphate, and kainite with 25 per cent potassium sulphate, the amounts are 3,465, 2,046 and 1,400 tons respectively, a total of 6,911 tons of these fertilizers. The Customs Department in its eleven returns published in 1939 shows that imports of fertilizers totalled 2,504 tons, so that the export of maize depleted the soil of Kenya by the equivalent of 4,407 tons of fertilizers. But fertility was exported at the same time not only as maize but also as coffee, wheat, potatoes, sisal, tea, cotton, pyrethrum and wattle".—*Ed.*

from the weathering of the rocks and the available supply is strictly limited by four factors, the composition of the rocks, their rate of weathering, the proportion of decomposition products that reaches the surface layers of the soil and the rate at which this occurs. If by over-cropping we remove them from the surface layers faster than they arrive, sterility must ensue.

Let us consider now how this works out in East Africa. The African with his primitive methods has long ago discovered that a given piece of land will not yield a crop indefinitely, and has therefore adopted the system of shifting cultivation at which so much abuse is so constantly hurled. It is, however, only fair to point out that the native does not move for fun. He dislikes it intensely. It involves him in a great deal of heavy labour. He moves because he has to and would starve if he did not.

Having worked out one piece of land he selects another plot, his choice depending in many cases on the type of vegetation upon it, which he has come to associate with certain soil properties. He then cuts down the trees and grass and fires the lot, which causes European heart-burnings, but provides him with a much-needed supply of ash as a fertilizer. When the plot is worked out he leaves it. Bushes and trees grow up, their deep roots tapping the sources of minerals in the sub-soil and conveying salts to the leaves, which eventually fall and restore fertility to the impoverished soil so that, barring destruction by erosion before vegetation has had time to cover it again, it becomes once more fit for cultivation.

Nowadays the African is being taught that this system is wasteful, and various schemes have been set on foot to make a respectable farmer of him. Side by side with a drive towards more and yet more crops, he has been urged to farm the same plot year after year by adopting rotations, which are invaluable as a means of supplying organic material and nitrogen to the soil, but can in no wise increase its mineral content because the essential salts come only from the weathering of the rocks. He has been urged to adopt scientific methods of mixed farming and composting, with which none could pick a quarrel were their limitations duly taken into account. But a misapprehension appears to have arisen that if only one has a cow all things are possible agriculturally. The wretched beast has had almost supernatural powers ascribed to her, she has become a sort of fertility symbol, and it has been forgotten that though a cow may be very useful in transforming matter or transporting it in her belly, she is quite incapable of creating it. She cannot defy the law of the conservation of matter, and consequently nothing can come out of her which does not first go into her.

Let us take an example. A peasant farmer is given twenty acres and a cow. He grows a cash crop, say cotton, food for himself and fodder for his beast. He is an industrious man and produces perhaps half a ton of seed cotton and a surplus of food which he sells. He buys a bicycle, puffs out his chest with pride and is held up as a shining example to his less enlightened brethren. Year by year he toils, the ideal painstaking mixed farmer—rotations, paddocks, legumes, catchcrops, milk sales, fodder crops, contour ridges—sheer joy to his teachers. But his yields fall, his cow sickens and dies, and one day, alas! he says he must move. What has happened? Every year he has been exporting minerals from his land, exporting at a greater rate than weathering has been able to replace them. In spite of his conservative methods, he has been, not an intelligent progressive farmer, but a poor fool living on capital. He has spent not a penny on importing fertility, but has squandered his plant nutrients on bicycles, trunks and clothes—trash so far as the land is concerned.

Rotations, mixed farming, anti-soil erosion measures and so on are essential if the best use is to be made of the land, because they help to conserve plant nutrients and prevent their wastage. But the conservation of nutrients is one thing, their creation quite another, and what we must realize is that no system of farming, however advanced, can possibly put certain essential minerals into the land which are not there, unless they are imported from elsewhere. Not even the poor cow can overcome this, for all she can do without imported feed is to assist in the transference of soil nutrients from the paddock to the arable land, with the consequent impoverishment of her own food supply. In Europe the process of deterioration is arrested by the use of "artificials" and by feeding the herds on cotton seed and groundnut cake taken from our peasant cultivator's land, a process which is in fact transferring the essentials of the black man's existence to the white man's pastures, thence, as we have already pointed out, to the millions in the towns and eventually via the sewer into the sea.

Without the importation of fertility in some form or other this process can go on

indefinitely only so long as the fertility exported does not exceed the annual increment of fertility produced by the weathering of the rocks of the country, and one of the most necessary pieces of research is an investigation into the value of that increment. Naturally it varies from place to place. Much of our river-valley land possesses considerable powers of recuperation; other areas like the central plateau country in Tanganyika are very slow in regaining lost fertility; and it is perhaps unfortunate that the richest land we possess is often unhealthy and sparsely populated.

An excellent example of a closely settled and heavily exploited area, where the parent rock is poor in plant nutrients and where the land is therefore slow to recuperate, is the coffee and banana belt on the western shore of Victoria Nyanza. The so-called Bukoba sandstone, as Milne* has pointed out, is markedly deficient in many plant nutrients, and consequently, though it weathers considerably faster than some rocks, its decomposition products are almost valueless. The Bahaya, in order to maintain their banana and coffee plantations, are forced to bring in grass mulch, cattle manure and crop residues from the open lands, which are thereby becoming progressively impoverished. The quality of the grazing has deteriorated until it has become some of the worst in the world (Milne, *op. cit.*), the cattle have become extremely infertile and are steadily decreasing, and even the value of the mulch as a fertilizer is diminishing. Those who know the area best declare that though the total yield has been maintained by increased planting, crop yields per acre have markedly declined during the last twenty years—the price nature charges in this region for exporting ten thousand tons of coffee a year and spending the proceeds on manufactured goods.

The same process can be observed in other parts of East Africa; does not one even hear of agricultural settlements barely a few years old already in difficulties over soil fertility? It is madness to blind ourselves to the grim truth that we are not only allowing, but earnestly encouraging, natives to export what is in fact more than the annual increment of soil fertility. They are living on capital and heading inexorably for agricultural bankruptcy in many areas.

The various schemes for introducing better farming methods prevent waste and encourage the more economical utilization of our resources, but they are mere palliatives so long as our export trade continues unbalanced by any adequate return of lost plant nutrients to the land.

There are only two economic ways open to us. Either the crop exports from any area must be reduced to balance the annual increment of fertility from weathering—and it seems likely that this would mean a very considerable reduction in many cases—or imported fertilizers must be applied to the land to make good the deficit. The former is unlikely to commend itself, while to the latter it will indubitably be replied that "artificials" are expensive and we cannot afford them. Are we any better able to afford to live on our capital?

"With adequate knowledge", says Professor Soddy,† "of the physical realities that dominate the economic affairs of peoples, the road is clear for unlimited progress and the attainment of universal peace and prosperity." He strips the science of economics right down to its basic principles, the fundamental physical realities, of which the ordinary economist too often stops short in his thinking, and sums it up in a few words: "The production of wealth . . . . . obeys the physical laws of conservation and the exact reasoning of the physical sciences can be applied. Wealth cannot be produced without expenditure, and a continuous supply of wealth cannot be supplied as the result of any expenditure once for all. Its production demands a continuous supply of fresh energy."

Our modern economic system has fundamentally altered the conditions of agricultural production in such a way as to draw recklessly on the stored resources of the land, too often without anything like adequate provision for maintaining a balance between what is drained from it and what is put into it, either by natural processes or by human agency; and where individual pieces of land are well tended, it is all too often achieved simply by a process of robbing some other pieces, perhaps the pastures next door, perhaps the fields of a distant continent, of their plant nutrients. We have become a generation of unparalled wasters of capital, the loss of which is likely eventually to hit the peoples of the world in a very tender spot.

* G. Milne.—"Bukoba: High and Low Fertility on a Laterized Soil", this *Journal*, Vol. 4 (1), pp. 13 to 24, 1938.

† F. Soddy.—*Wealth, Virtual Wealth and Debt.*

(*Received for publication on 20th December, 1942*)

COMMENTARIES ON MR. CULWICK'S ARTICLE

Mr. Culwick has done well to call attention to the tremendous drain of plant food which is going on away from the primary-producing to the industrialized countries. The maize, cotton-seed, groundnuts, sesame, cocoa, coffee, wheat, bananas and other produce yearly exported from some parts of the world to others must reach tremendous proportions. However, do not let us fall out of the frying-pan of economics into the fire of polemics. Let us get the thing into proper perspective. The great bulk of what we export is carbon hydrogen, oxygen and nitrogen, all of which we can replace by natural means on the spot if we will. Of the elements of which there is an inevitable drain in export crops, only phosphate and potash are really significant, perhaps with one or two lesser known elements in particular areas. Do not let us ascribe all declining fertility to loss of minerals, when we know that loss of humus and loss of soil play a large part. There is a classic experiment at Rothamsted in which, after an initial decline in yield, a constant stage was reached in which, apparently, gain balanced loss. The amount of various elements removed in a thousand tons of rice, as given by Mr. Culwick, sounds impressive, but perhaps would be less so if expressed in terms of the reserve from which it is drawn. Two thousand acres of rice land must contain large quantities of those elements in and under the soil. We shall be in a better position to judge when the investigation suggested by him has been made and a profit-and-loss account prepared.

Neither should we regard this as entirely a "native" problem, and place a weapon to the hands of those whose solicitude for African soil does not go beyond the soil of their African competitors in the market. It is a problem of every agricultural area which sends fertilizing material into the sewage system of towns. It is a great pity that the material is simply destroyed instead of being converted by chemical means into fertilizer. Every agricultural area is affected, though less so in the proportion in which industrial by-products, such as oilcake, are returned to the same land. Human beings insist on congregating, and because they will not go to the minerals the minerals must be taken to them; they will waste them just as much if they live on the farms where crops are grown as in the cities. Few people yet convert their night-soil into compost, except in China and Japan.

And, Micawber-like, we may hope to be saved by events. The industrialized countries are showing signs of reaching a stage of declining population and their needs of minerals may similarly decline. The tropics may become more industrialized and thus drain away fertility into their own towns instead of into other countries. The advance of the plastics may result in the tropics concentrating on the production of cellulose. The tropics may come to export oil instead of oilseeds, the minerals in Tanganyika cottonseed and groundnuts may find their way to Kenya dairy farms instead of English pastures, and butterfat with no minerals except common salt may be sent on to over-populated Europe. And finally, until we have drawn up the profit-and-loss account, for all we know our descendants may be living on what is now the Atlantic ooze before the exhaustion of the soils of the African continent is complete. V.L.

On the soil side the case is overstated. In Uganda at any rate we have come to the conclusion that soil fertility is more a matter of physical condition of the soil than its chemical composition, and we aim at the maintenance of soil fertility by the grass rotation. We do not belittle the drain of nutrients and, in fact, have put up parallel figures to Mr. Culwick's in our Annual Report (1936), but we maintain that if soil erosion can be prevented by building up the structure of the soil and by strip cropping we shall not have to stop growing crops for export. E.F.M.

As the general framework of civilization becomes more complex, the importance of adequate administration and control becomes crucial. Anarchic private interests on the one hand or stupid bureaucracy on the other can destroy most of the potential value that might accrue from technical advances. We need to apply science to the field of administration, or civilization will choke itself with its own products.

Prof. J. D. Bernal in *The social function of science.*

EARLY LAND IMPROVEMENT

I will open rivers in high places and fountains in the midst of the valleys: I will make the wilderness a pool of water, and in the dry land springs of water. I will plant in the wilderness the cedar, the shittah tree and the myrtle and the oil tree; I will set in the desert the fir tree, and the pine and the box tree together.

Isaiah, chap. 41, verse 18.

CANALIZATION OF TAPERING STREAMS

By C. G. Fane, Public Works Department, Kenya

The small rivers and streams of Kenya are mostly tapering, especially where they run through farm lands, denuded of forest.

Much seepage is caused by water disappearing through fissures in the stream beds and a certain amount by cattle poaching up the bed at wide and shallow drinking places.

In some cases small rivers which leave the forests at a rate of 2 cusecs (or 1,076,000 gallons per day) are reduced to nil in a distance of 20–40 miles.

The following notes and sketch show that a very small channel will carry 1,000,000 gallons per day at far less cost than a pipe line.

Assume channel to be 1 ft. 6 in. deep, 1 ft. bottom width, 1—1 side slopes and 4 ft. wide across the top.

Assume a grade of 1 *per cent*, which is a common slope on many small rivers. (Some fall at 3 per cent).

The steeper the slope the greater the discharge.

Using Manning's formula:

$$V = \frac{1.486}{n} \times r\,0.67 \times S\,0.5$$ (where n = 0.025 for earth channels)

Then velocity is 2.69 feet per sec.

Discharge is 2.02 cusecs or 1,085,000 gallons per day. This velocity is rather high and might result in scour. There would also be some seepage in an earth channel.

So I suggest using—

(*a*) a *bitumen carpet* (as used on roads) 1 in. thick on the floor of channel and up the slopes of same, or

(*b*) a *brick-lined* channel, or

(*c*) a *stone-lined* channel.

In each case a small catch-water drain is necessary, to prevent storm-water flooding the main channel.

Any of the above treatments would make the channel watertight, improve its hydraulic efficiency, prevent seepage, and ensure clean water.

There is nothing new in the above methods. Bitumen has been largely used as a canal lining in various parts of the world for many years, and in earlier times, both stone and brick linings were common.

Method of construction.—First, select a site for the intake or "forebay". There are two good types of site: (*a*) a wide and shallow point on the river, or (*b*) a point above a waterfall or rapid. If (*a*) is chosen, a low weir, say 2 ft. high, is built of rocks, possibly cemented, from bank to bank, to ensure a constant level at the intake at low water. The slopes of the weir should be 3 to 1, to allow flood water to flow over in an easy curve, and not scour below the weir.

The intake consists of a concrete box, say 4 ft. × 4 ft. × 4 ft., with automatic stop valve (i.e. as in the ordinary cistern) which admits, say, 2 cusecs, no more and no less, into the main channel which leads out of it.

If the waterfall type of site is selected, the following method should be adopted. Choose a point for the intake just above the waterfall, at the low-water level of the stream. Starting here, a brick-lined channel, 100 ft. long, falling on a grade of 0.2 per cent must be constructed, to lead into the main channel, with which it communicates through a concrete box. This concrete box contains a small gate, which when lifted will admit, say, 2 cusecs into the main channel.

A spillway 30 ft. long must be left in the side of the intake channel nearest the river, to prevent flooding, and to return surplus water to the river.

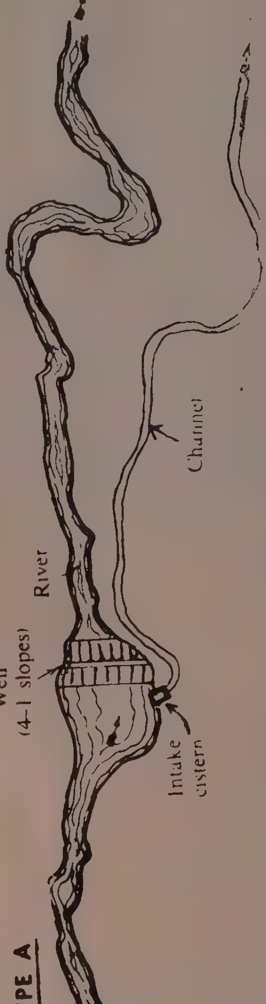
The discharge of the main channel is approximately equal to that of a 9 in. pipeline on a 1 per cent grade (which, it may be noted, would cost about £5,000 a mile laid).

If the stream bed runs through a regular valley like that, for instance, of the Rongai River, the construction of the channel is easy; it merely follows the contours on an even 1 per cent grade. If, however, there are abrupt drops in the river bed, the level of the channel would have to be dropped to a lower level by small timber flumes, or 12 in. by 12 in. square wooden pipes.

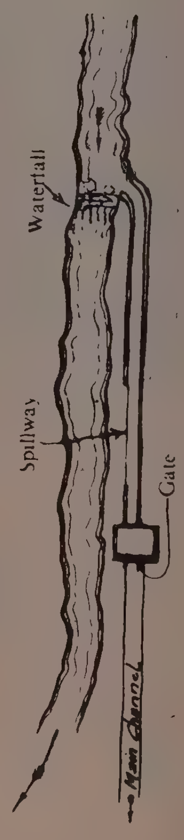
Quantity of water made available.—Assume a tapering stream leaving the forest and running into the head of a series of farms at 1,000,000 gallons per day, thence passing through, say, 40 riparian farms in 20 miles.

1,000,000 gallons divided between 40 farms is 25,000 gallons per farm per day. 5,000


Channel area = 3.75 sq. ft.
Spoil dump
Bitumen carpet 1" thick
W.L.
Waterway area = 0.75
4'
2.12'
A = 0.75
Slope = 1 per cent, or 10' per 1,000'
p = 1 + 0.71 + 0.71 = 2.42
r = A/p = 0.75/2.42 = 0.3074
Using Walmsley's Nomogram
V = 2.7 ft. per sec.
Q = 2.1 cusecs
= 1,128,000 gallons per day


River
Channel
Weir (4–1 slopes)
Intake cistern

TYPE A


Waterfall
Spillway
Gate
Main Channel

TYPE B

gallons per farm would probably be sufficient, the balance of the water would be available for new developments, and in the meantime would be returned to the river at the end of the twentieth mile.

As things are at present, the last or lowest farms on a tapering stream often get no water at all in the dry season.

APPENDIX

COSTS PER MILE

A. BITUMINOUS LINING

	Sh.
(1) Channel excavation (Area=3·75 sq. ft) 3·75 × 5,280′=19,800 cu. ft. at Sh. 20 per 1,000	396
(2) Catch-water drain 1 ft. deep to protect channel from storm water 2′ × 5,280′= 10,500 cu. ft. at Sh. 20	210
(3) A common contract price for 1-inch carpet is Sh. 1 to Sh. 1/50 per sq. yd. taking the latter figures 5·24 × 5,280′=27,667 sq. ft.=3,074 sq. yds at Sh. 1/50 ..	4,611
(4) Fencing both sides at £20 per mile : £20 × 2 =£40	800
	6,017
Plus 20 per cent supervision	1,203
TOTAL .. Sh.	7,220

B. BRICK LINING

Bricks 9″ × 4½″ × 2½″=0·75 × 0·35 × 0·21
Three bricks laid 9″ longitudinal for canal bottom.
Six bricks laid 4½″ longitudinal for canal sides.

	Bricks
Bottom—5,280 ÷ 0·75=7,920′ and 7,920′ × 3	=23,760
Sides—5,280 ÷ 0·35=15,086 and 15,086 × 6	=90,516
	114,276

The costs are given in the Appendix. They are approximate only, as these naturally vary in relation to the length of the haul, and the cost of materials in different districts.

Without taking costs into consideration, I personally would prefer to use brick lining for the channel wherever possible, owing to its ease of construction and repair.*

Assume cost of common bricks plus laying at Sh. 60 per 1,000, therefore 114,276 at Sh. 60 per 1,000= Sh. 6,856=£342 16*s*.

	Sh.
(1) Channel excavation (as before)	396
(2) Catch-water drain	210
(3) Brick lining	6,856
(4) Fencing	800
	8,262
Supervision at 20 per cent	1,652
TOTAL .. Sh.	9,914

C. STONE LINING (9″ × 6″ stone)

Eight stones required. 5,280′ × 8=42,240 lineal feet of stone, therefore 42,240′ at Sh. 30 per 100 laid= Sh. 12,672=£633 12*s*.

	Sh.
(1) Channel excavation	396
(2) Catch-water drain	210
(3) Stone lining	12,672
(4) Fencing	800
	14,078
Supervision, etc. at 20 per cent	2,818
TOTAL .. Sh.	16,896

* Experiments with various types of lining of small canals will shortly be carried out by the P.W.D. These will include the types of lining suggested in this article.

(*Received for publication on 2nd May, 1943*)

As a novelty, the potato faced the unreasoning opposition that is the fate awaiting all innovations, good or bad. It was preached against, written against and fought over. Its omission from Biblical mention earned it the suspicion of some; its supposedly deleterious effect on the mind aroused the dislike of others. Sneered at in France, it subsequently grew to such esteem that Marie Antoinette wore its flowers in her hair and set an aristocratic fashion. Hated in Prussia and the subject of the dictatorial decrees of Frederick the Great, it eventually saved the country from starvation in the Seven Years' War. Mentioned as a dainty by Queen Anne, it progressed in time to become the staple foodstuff of Ireland. As a vegetable it is now easily first in popular favour throughout the length and breadth of the land.

Dr. J. C. Wallace: *Potatoes.*

It must ever be borne in mind that identification and correct naming, though the first essential steps towards the investigation of a plant, are nothing more. They constitute the indispensable means to another end, namely the inexhaustible study of the structure and activities of the organism, but can never be an end in themselves.

A. R. Horwood: *British wild flowers in their natural haunts.*

AN ANCIENT LIBEL ON EAST AFRICA

The land of Zanj is so hot that the celestial bodies draw humours into the upper part of the body, so accounting for projecting eye-ridges, hanging lips and unbalanced brains.

An Arab geographer *circa* 950 A.D. quoted by Eric Axelsen in *South-East Africa*, 1488–1530

SOME INDIGENOUS VEGETABLE FIBRES

By V. A. Beckley, Senior Agricultural Chemist, Department of Agriculture, Kenya

Prefatory Notes.—This article is based upon a survey of many types of local fibres conducted to search for a fibre suitable for the production of fishing nets for the fishing industry on Lake Victoria and for fibres suitable for the making of brushes and brooms. By far the greater number of fibres examined were collected by Mr. Greenway, Systematic Botanist at Amani, who has been most assiduous in obtaining fibres of every type.

In writing this article, technicalities have been left out. It is desired to give a general picture of the fibres which are, or could be, produced in East Africa.

Generally, when speaking of fibres, one has a very definite picture in one's mind confined, in most cases, to a single fibre or class of fibres—a sisal man, speaking of line fibre, is referring to "sisal line fibre"; whereas a flax man by the same term is thinking only of "flax line fibre". Vegetable fibres are most varied in their characteristics and in the thickness of the individual fibres. At the one end of the scale are the fine fibres of flax, ramie, or cotton, and at the other end the very coarse, stiff fibres known as piassava. It is not surprising, therefore, that the fibre trade is highly specialized and special classifications are employed for each group of fibres. For the sake of simplicity, a general classification is being attempted to cover the whole gamut of vegetable fibres.

Very fine fibres can be classified, or can be termed, the soft fibres, and these again divided into two groups, spinning fibres and fibres for special purposes. Into the first category would fall flax and cotton, etc. Such fibres form the staple of the vegetable fibre fine-spinning industry. They can be spun into very fine yarns, indescribably fine, or, when desired, into heavy, coarse yarns. In the second category fall such fibres as kapok, whose main use is as a stuffing material; it is unsuitable for spinning.

The next group of fibres may be termed the semi-soft, those which constitute a group of fibres often termed jutes. True jute is a definite and well-known fibre, but there are a great many that approach closely in characteristics and appear on the market as "such and such jute", e.g. Bimlipatam jute. These semi-soft fibres are practically confined to the manufacture of coarse fabrics such as hessian and sacking. Perhaps, into this group should also fall the true hemp fibres, whose main use lies in the manufacture of fine cordage.

The next group may be termed the hard fibres, and this group should be restricted to those fibres which are suitable for the manufacture of ropes and cords generally, although some of them are employed for sacking. Into this group fall manila hemp, sisal, and other agave fibres and some of the Sansevieria fibres. It is not easy, however, to draw a line of demarcation between this group and the previous one. There is a gradual merging of some of the semi-soft fibres into the finer hard fibres.

Finally, one comes to the group of fibres which may be termed brush fibres; these vary enormously in thickness, but are all characterized by great resiliency which makes them suitable for the manufacture of brushes and brooms. Here again there tends to be a merging of the group of hard fibres into the brush fibres; some of the agave fibres, for example, are sometimes used for spinning and, at the same time, are highly suitable for brush fibres.

Another classification of fibres which is useful at times depends upon origin. There are the fibres derived from, or connected with, the main vascular system of monocotyledonous plants; there are the fibres derived from the stem bast of dicotyledonous plants; there are those derived from seed hairs; there are yet others of varied origin.

East Africa is very rich in fibrous plants, and from time immemorial certain of these have been used by natives. They produce a cloth from the bark of certain fig trees; they use strips of bark torn from a host of plants for use as string or as light ropes. They extract the fibres of certain plants for the manufacture of bags, for bow strings and fishing lines. They even produce ropes from the leaves of certain palms. But with the exception of Sansevieria there has been no real attempt on the part of the Europeans to exploit the indigenous fibre plants.

Possibly because they have been utilized by natives, the Sansevierias attracted the attention of early settlers and quite an industry

developed in their exploitation of the fibre.* As a genus, the Sansevierias are extraordinarily varied in growth and habit and certainly most people would not be able to recognize all the forms. Some of them are miniature plants with thick, fleshy leaves a few inches high, some have single cylindrical leaves, others semi-cylindrical leaves arranged in a fan, while yet others have flat leaves. There are also arborescent species with leaves arising from a thick stem. It is much to be doubted if the systematics of this genus have been fully worked out yet; for example, there are a number of forms that have cylindrical leaves and which have been named *S. cylindrica*, but if the type of fibre carried is any criterion, it is probable there are several species or varieties.

The fibre of Sansevierias is characterized by a great variation in thickness. If a single leaf be very carefully decorticated, it will be found that there are always two classes of fibre present, the dominant fibre comparatively coarse and varying in thickness about a mean, the other very fine and silky. It is sometimes rather difficult to separate the silky fibre, without damage, from the dominant coarser fibre.

The coarsest fibre so far encountered was a semi-round Sansevieria found in the Kitui district. It is not known to which species the plant belongs as only a few leaves were submitted. The dominant fibre was rather thicker than the lead of a lead pencil, stiff and rather quill-like. Mixed with it was a quantity of finer fibre which conld be fairly readily removed. The coarse fibre is very strong and resilient and would be suitable for the manufacture of coarse brooms. A very valuable brush fibre is derived from *S. stuckyi*, which grows profusely in Somalia and was exploited by the Italians. The fibre is comparatively fine for a brush fibre, being slightly thicker than horse hair, and is very stiff and resilient. The separation of the coarser fibre from the fine silky material involves a certain amount of trouble, but it used to be done by the local natives, giving a fibre which would be suitable for the manufacture of paint brushes, soft brooms, clothes brushes, etc. Perhaps, in short lengths, it would be suitable for nail brushes.

A very interesting fibre was obtained from a tall, semi-cylindrical species of Sansevieria, the name of which is not known. It was found growing at Taveta. The dominant fibre varied considerably in thickness; the coarsest fibres were of a thickness of a heavy salmon-cast and graded down in the finest to the thickness of a 30s cotton thread. The fibres from this species demonstrated very clearly one of the real weaknesses of the Sansevieria fibres. A straight length of the coarse fibre would support a weight of 20 lb., and often more, but if a single simple overhand, or even figure-of-eight knot were made in the fibre, it broke at the knot under a weight of not as many ounces. The break appears to be almost as sharp as a cut with a knife; in fact, one might almost say that, when knotted, the fibre cuts itself. On first inspection, the fibres derived from this species appeared to be suitable for heavy cordage, but the very great loss of strength, when knotted, demonstrated the very great danger of a rope made from this fibre failing suddenly when put under strain. Perhaps it is because of this fault that Sansevieria fibres became unpopular on European markets.

Very promising fibres are derived from the *Sansevieria cylindrica* group, which provide an enormous variation in texture of fibre. Maybe, we are dealing with different species or varieties; maybe the effect is climatic, considering climate as including soil climate. The fibre from one type, from plants found in the Northern Province of Tanganyika, is very much like sisal in feel and is strong when tested in the straight, but it does suffer from the disadvantage of being cut when knotted. Possibly the fibre could be utilized for heavy cordage if the twist and lay of the ropes is not too sharp. From similar plants found at Mwatate a very much finer fibre was extracted which showed less tendency to cut when knotted. A small member of the same group found at Ruiru yielded the finest of the Sansevieria fibres I have seen. This fibre will spin into fine twines of great strength and although the fibre still has the disadvantage of cutting itself when knotted, in the form of fine twine it requires considerable force to break it at a knot. If this plant could be grown in quantity it would provide a very valuable fibre for a variety of cordages and for coarse fabrics.

Continuing down the scale of fineness we come to the fibre derived from *S. kirkii*, which is rather finer than that of blue sisal. The fibre produced from plants growing in the Northern Province of Tanganyika was four feet long and very strong. A sample received from Somalia, reputed to be derived from this Sansevieria, was distinctly finer but only about 30 inches long. Perhaps here, if the species be really identical, we have a further indication of the effect of climate.

* See this *Journal*, Vol. 7 (2), p. 96, October, 1941.

Finer fibres yet are derived from *S. braunii* and *S. volkensii*. All of these fibres would be of value for cordage and, if one could only make certain that the plants being exploited belonged to these three species, a good commercial fibre would be produced.

One of the real disappointments in this group of plants is a species with flat leaves, probably *S. guineensis*. The fibre from this species is very easily extracted with ordinary sisal machinery. It is long and pliable and almost as fine as that derived from the small *S. cylindrica* found at Ruiru. Samples of this fibre were submitted to the British cordage trade and so encouraging were the reports that several attempts have been made to grow the plant on a commercial scale. The attempts have been failures. Very small stands developed and the plant, under cultivation, will not tolerate cutting, although in the wild state it can be quite heavily cut without damage. There is yet another very serious disadvantage—the leaves have hard red edges which, on decortication, appear as stiff red fibres which not only spoil the appearance of the rest of the fibre but also detract considerably from its value. Several other species have also been tried under cultivation and, here too, on the whole results were disappointing. Only one species shows any promise and it is yet too early to make any definite statement regarding it. As far as the others were concerned, multiplication was slow and the plants appeared to be intolerant of any attempt to control them.

From the above it will be gathered that although the genus *Sansevieria* does contain valuable fibres that would be of importance at present, the exploitation of wild plants is very chancy. It is difficult to make certain of the exact species or variety required and then it may be scattered in small blocks over a wide stretch of country. Collection would be difficult and expensive, and if mixed species were collected the resulting fibre would be very variable in texture and of highly problematic commercial value.

One of the most important of the group of hard fibres is manila hemp, derived from *Musa textilis*, a type of banana. This fibre, as perhaps everyone knows, is the standard rope fibre throughout the world. The fibres themselves are rather hard to the feel, flexible, but individually very strong and, while still liable to cut themselves when knotted, do not show the very great loss of strength evinced by the Sansevieria fibres. *Musa textilis* is grown in East Africa to a very small extent, nowhere on a commercial scale.

The ordinary banana carries a fibre which can very easily be extracted by means of a raspador. The fibre is finer and softer than manila hemp but, at the same time, is still strong. It would be suitable for many types of cordage. Samples have been sent to Great Britain for report and, if the result is encouraging, it should not be difficult to work up an industry, utilizing the numerous plants grown by the natives. There are several indigenous species of *Musa* in East Africa. I saw fibre extracted from the common wild banana of Kenya, *M. livingstoneana*, a number of years ago. Speaking from memory, the fibre is rather finer and softer than that from the ordinary banana. The fibre would be of great value but, as the plants are very widely scattered in heavy rain forest, it would be most expensive to attempt commercial exploitation. A number of years ago a few plants of this species were grown at the Scott Laboratories and they developed into huge plants, quite as big as any seen in the forest; so it appears it would not be difficult, given suitable climatic conditions, to establish a plantation, but before any steps could be taken in this line a full commercial valuation of the fibre would be necessary. The same remarks refer to *M. holstii*, a Tanganyika species. The fibre from this plant is most attractive; it is fine, strong, pliable, and has a silky sheen. If it were possible to produce this fibre on a commercial scale, I have no doubt that it would rather rapidly make a place for itself in the world's fibre markets.

A most interesting species, *Musa ensete*, occurs in the forests of Abyssinia; the leaves carry a beautiful, fine, pliable, soft fibre. The seeds, it is understood, are used for the feeding of infants, the roots are fleshy and are used by the natives as a food in times of famine. The fibre has long been used by the Abyssinians and exported to the tribes around Lake Rudolf, who use it in the making of fishing lines and nets. It was also exploited by the Italians, who used it almost exclusively in one of their bag factories. The fibre can be spun down into a really fine twine, 12s, which would be suitable for the making of nets required on Lake Victoria. An experimental net was made of this fibre but, unfortunately, the native spinning was rather poor—the type of fibre was different from that to which they were used. Possibly they would soon learn to spin this fibre properly. A sea net was also made from this fibre and was found to be most attractive; it possessed a good deal of life and showed no signs, when subjected to heavy

strain, of any tendency to break at the knots. Seed of this species has been obtained from Abyssinia and plants will be distributed to various parts of Eastern Africa—if not for commercial use, at least for the use of the native.

Note.—In describing some of the above fibres, the term "soft" has been used. The term has been applied purely in a comparative sense and must not be thought to indicate that these fibres fall into the group of soft fibres; all the above fibres really fall into the group of hard fibres and are suitable for use in the production of cordage or of coarse textiles.

From the palms, another group of fibres can be obtained. Although the leaflets, or strips of the leaflets, of many palms have been, and are being, used for weaving coarse matting and baskets, these strips of material cannot really be described as fibres. There are true fibres present in most of the palms, many of which are highly suitable for the manufacture of brushes and brooms. Probably th commonest wild palm in East Africa is the Doum palm (*Hyphaene*). Its leaflets have been used for generations for mats, baskets, and basket work generally. One of the tribes of the Northern Frontier Province of Kenya spin a coarse rope from them, but no other real use was made of this palm. A few years ago the Officer in Charge of the High Level Sisal Research Station found that it was possible to extract from the butts of mature leaves a coarse stiff fibre, very similar to the finer types of piassava fibre used in the making of scrubbing brushes and hard brooms. The method of extracting the fibre is simple. The dried butts are beaten with wooden mallets to separate the fibres from the connecting tissues. Fair quantities of this fibre are now being produced for the production of much-needed brooms and scrubbing brushes. The finer qualities are mixed with sisal fibre to make whitewash brushes. Another fibre can be obtained with a fair amount of trouble. This is the stiff, fine fibre which separates from the edges of the young leaflets. From examination it appears that this fibre would be highly suitable for whitewash brushes and coarse paint brushes. Unfortunately, however, it has not been possible to arrange for the production of this fibre on a commercial scale.

Another common palm in East Africa is the *Raphia*, from the young leaflets of which the well-known raffia "fibre" or bast is obtained. A very valuable fibre, so far as present-day requirements are concerned, can be extracted from the leaf bases and also from the stems. This is a coarse, heavy piassava, about one-tenth of an inch in diameter. The fibre is being produced in medium quantities and used in the making of heavy bass brooms. The extraction is not simple. It requires very severe retting, followed by pounding with wooden mallets.

Several other "fibres" are being produced to meet the need for brushes of all sorts. The tips of the leaves of the Makindu palm, *Phœnix reclinata*, are being made up into heavy brooms suitable for street sweeping or for garden use. The roots of certain grasses have been found to possess sufficient stiffness, pliability and resilience to make them suitable for use in the manufacture of scrubbing brushes, but none of these can really be called true fibres.

From several other monocotyledonous plants fibres can be extracted; some of these, on superficial inspection, appeared to be most promising, but on further study were found to suffer several disadvantages. Some of the fibres are strong, pliable and resilient when the atmosphere is humid, but become very brittle under dry conditions. Others lose all resiliency when wetted, which completely spoils them for the uses to which they are otherwise most suited. It is, therefore, not considered worth while describing any of these fibres here.

In monocotyledonous plants, the structural fibres are more or less parallel and can be extracted by simple mechanical means. In dicotyledons, the structure of the fibres, which can be utilized are, more often than not, branched and run into one another, forming a sort of basket work. This structure can very easily be seen if one strips the bark from a twig of one of the wild hibiscus plants used as string by the natives. On the inner surface, a sort of basket work will be seen. The extraction of fibres, therefore, requires more difficult methods of treatment; wetting or scraping of individual strips of the bark. These bark fibres, more correctly termed "bast" fibres, constitute some of the main fibres of the textile world. Besides these, most important fibres exist in the form of seed hairs, the most outstanding example of which is cotton.

The hibiscus family (*Malvaceæ*) is very well represented in East Africa. Strips of the bark of many species have long been used by the natives for rough cordages, but very little indeed has been done to utilize the wild plants for the production of clean fibre. Some years ago, attempts were made to utilize *Hibiscus cannabinus*, a very common plant in many parts of East Africa. This plant is grown in India on a commercial scale for its fibre, which is known on the market under the name of Bimlipatam jute and is prepared by a system

of retting. Experiments were made locally on a new type of sisal machinery which produced a very attractive fibre, but it was not found economic to collect the wild plants, and when attempts were made to grow the plant it suffered severely from damage by insect pests.

Urena lobata is another indigenous malvaceous plant which is elsewhere grown on a commercial scale for its fibre. It is being grown commercially in the Belgian Congo, where it gives lengths of fibre six feet long, silky and soft, closely resembling really good jute. In Kenya, the wild plant is very seldom more than eighteen inches to two feet high and very heavily branched, whilst plants grown from seed obtained from the Belgian Congo were no more than three feet high, so that it would not appear worth while to consider utilizing this plant here.

Many of the other Malvaceæ are worthy of investigation some time or other. The fibre is produced by retting which, on experience, is not very difficult. It is not worth while continuing the experiments at present as the spinning machinery in the country is not really suited to the spinning of these softer fibres. Incidentally, some of the wild Malvaceæ carry seed-hairs, but these are so short as to be of no commercial value.

A most attractive seed-hair fibre is that carried by many species of the family *Asclepiadaceæ,* the milk-weeds. Many attempts have been made to find a use for this very attractive fibre but without success. It does not lend itself to spinning, it is brittle and so cannot replace kapok as a stuffing for pillows and mattresses, but it is of interest to note that it is being utilized in the United States for the stuffing of swimming jackets and bridging bolsters as it has almost as great a buoyancy as kapok. The bast fibres of this family are most attractive and have a great tensile strength; they are also fairly easily extracted and ropes have been made from such fibres by certain native tribes in East Africa. The fibres, however, are curiously "dead" and have very little elasticity. I have seen a jumper knitted from a yarn made of fibre extracted by a native from a species of Asclepiad found in Southern Tanganyika. The workmanship throughout was excellent, but the garment itself was heavy and had no elasticity. A use has been found for the fibre in the United States, too. It is a very pure form of cellulose, very suitable for the production of rayon, but, as far as East Africa is concerned, it is feared that asclepiad fibres are at present of no commercial value.

It is possible to continue enumerating fibres derived from indigenous plants, but in almost every case there is some reason against their utilization. For example, a most attractive soft, strong fibre is extracted by natives in the neighbourhood of Lake Nyasa from the bast of *Pouzolzia hypoleuca,* a member of the family Urticaceæ. This fibre is very similar to ramie and, like ramie, is extracted by hand; no machinery has yet been evolved which will extract ramie fibre properly. True fibre can be won by retting, but this fibre cannot compare with hand-extracted fibre; during retting the colour is spoilt and, worse still, the fibre is partially broken down into its ultimates and, therefore, is weakened. Thus, attractive as this fibre is, the need for hand extraction prevents its use commercially.

The conclusion arrived at as a result of this survey of indigenous fibres is that, while some fibres belonging to the categories of brush and hard fibres can be produced commercially, the vast majority of local fibres cannot, even under present conditions, replace established fibres such as cotton, linen and sisal. The development of the synthetic fibre industry will effectivly prevent even the most promising of the softer fibres from entering the textile world.

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WRITE SIMPLY

They said: "It is apparently the case that the alkaloids are present in high proportion."

Try: "The alkaloids appear to be present in high proportion."

They say (*constantly*): "The termination of hostilities" or "the conclusion of hostilities."

Why not: "The end of the war"?

They said: "Climatic conditions unfavourable to agriculture have existed for a protracted period."

Try: "For a long time the weather has been bad for agriculture."

They said: "His advisers rightly decided to bend their main energies to extending the group system until it became countrywide in coverage."

Try: "His advisers rightly decided to concentrate on extending the group system until it covered the whole country."

TRAINING IN AGRICULTURE AND ANIMAL HUSBANDRY

At the Government Teachers' Training School, Mpwapwa, Tanganyika territory

By R. J. Harvey, Headmaster

Situated in the Central Province, one of the driest areas in Tanganyika, Mpwapwa has a rainfall varying between 17 and 35 inches annually, averaging from 20 to 25, and falling almost entirely between December and March. It is at an altitude of approximately 3,500 feet above sea level on a slope which averages 1 in 17 and on highly erodible soil. To the north lies the Kiburiani massif, rising to 6,500 feet. The people of the Central Province are mainly pastoral, and though boys are admitted to the school from other provinces, it is the local background which has to be borne in mind in any system of agricultural training. This may be summed up as dry, highly erodible land, subject to heavy rain storms; miles and miles of bush producing an ephemeral pasture during the rains, but through which half starved cattle eke out a bare subsistence during most of the year; its main needs are anti-erosion work and pasture making.

The boys are housed in "villages" that is groups of small dormitory huts, each village having its own refectory and kitchen and having its own *shamba,* worked entirely by the boys themselves, there being about 40 boys to a village. Besides these, there is the school farm, worked largely by paid labour, but on which all schoolboys assist and so have a practical insight into its working. The farm has a dairy herd and working oxen.

The Village Shambas.—The primary object of these is to give the boys, who are teachers in training, a personal and intimate knowledge, throughout the three years of the course, of the running of a *shamba* suitable to a village school in this area. Though the size of such village school *shambas* would vary according to the number of children in the school big enough to work them, the proportion of the different areas, as set out below, to each other would remain constant. A secondary consideration is an attempt at producing an improved African small-holding. The "village" *shambas* at Mpwapwa are divided as follows:—

(*a*) Two acres divided into four half-acre rotational plots, consisting of two cereals, maize and millet, and two legumes, beans and groundnuts. This is essentially a two-crop rotation, suitable to the type of soil, but four crops are grown for variety. The whole area is contour-banked and ridge-planted on the contour.

(*b*) Two acres contoured and planted with star grass (*Cynodon*) and left fallow. Every four or five years this is alternated with (*a*), thus combining the merits of fixed and shifting cultivation, but emphasizing the use of a grass fallow. The grass is cut periodically and used either for compost or hay and it is periodically grazed by cattle.

(*c*) A half-acre plot used for fruit trees and vegetables. The former consist of grapefruit, orange, lemon, lime, soursop, carambola, mulberry, guava and pawpaw. Both European and native vegetables are grown in small terraced plots, and two or three big contour banks traverse the whole. Some of these plots are used for experimental purposes and as a plant museum. This year, for instance, varieties of Soya, Tepary, Goa and French beans and cowpea have been obtained from the East African Agricultural Research Station at Amani. Those which are successful will be planted on a more extensive scale next year. This area is heavily composted to maintain soil fertility and to make suitable soil for vegetable growing. Any spare plots are planted with legumes to maintain cover and soil fertility.

(*d*) A half-acre plot divided into two, one half pigeon pea and one half cassava. These are used as an example of famine crops and are rotated. As some types of cassava take up to two years to mature, pigeon pea is the most satisfactory legume for rotation with it, besides being in itself a useful famine crop.

(*e*) A firewood plantation which will eventually extend to about two acres is also maintained by each village.

Flowers are grown in the actual village compound and shade trees have been planted. Each village has two or three compost pits.

The School Farm.—This consists of some 250 acres, of which about 25 are arable, 15

used for grazing during the early rains and later left for hay, about 120 acres of pasture in various stages of development, and the remainder bush which will gradually be cleared.

Though the greater part of the work on the farm is done by paid labour, boys take sufficient part to familiarize them with all activities. They thus acquire a working knowledge of animal husbandy and its ancillary work, pasture making and the production of dry-season cattle feed, such as should enable them to take a leading part, as teachers, in such community or other activities as may be undertaken by the people among whom they work.

It has already been noted that the farm work is planned for an area which is primarily pastoral. Though a certain amount of food is produced for the school, especially in time of shortage, the crops grown are chiefly maize and cowpea for silage and hay.

The school herd is the focus of activity. At present it consists of 25 cows in the dairy herd, with working oxen and calves. Cows are milked in the morning only, and for the remainder of the day their calves remain with them, but are shut up separately at night. This ensures both a fair supply of milk and also that the calves themselves get sufficient. No hand-feeding is done. Since the herd is run primarily as a demonstration of what could be done by an intelligent African on his own, it is felt that hand-feeding raises too many difficulties; for instance, scour due to dirty containers. The system ensures adequate food and consequently growth for the calves. Another important factor is that the calves ensure that the cows are fully milked out. A minimum of a 250-day lactation with 1,000 pounds of milk is aimed at. This may appear low, but practically all cows are of pure native stock and a dry season of about seven months is the average, during which cows must be fed.

All boys take their turn in the school dairy, where they are taught milking and the making of a clarified butter.

In many ways the chief work of the farm is pasture making. Bush is cleared, the ground is contour-ridged and then planted with the perennial star-grass. Boys take part in all operations except for heavy stumping and can see the whole range from good pasture down to practically useless bush.

As has already been indicated, another important feature is dry-season feed, and the main purpose of the farm is to produce cattle feed. This is essential to milk production in such a dry area. The bulk consists of ordinary hay with leguminous feed in the form of cowpea hay and a certain amount of maize silage. Milking cows are also given cotton seed, and some lucerne is grown under irrigation for the calves.

Most of the maize grown is cut green for silage, but some is left to ripen. The stalks are then cut and stacked and a small amount is thrown daily into the cattle pen, the cattle eat off what they want and the hard stalks are trampled in. A particular point is made of throwing as much dry vegetable matter as possible into the cattle pen and so obtaining the maximum amount of manure. This is then stored in pits and returned to the land as required.

Again, some of the cowpea is harvested and used for school food, after which the stalks are cut and stacked for fodder. The reason for this apparent inconsistency is that few Africans are likely at present to produce food crops for cattle fodder, so demonstration is given not merely of the best way to utilize such crops for fodder, but also of alternative methods by which some benefit may be gained even if crops are required for human consumption. The latter also occurs at times of general shortage, when everything that can be grown is required for food for the boys. At the same time, since this is not a truly agricultural area, it is normally more economic to produce cattle feed ourselves and to buy food for human consumption from other areas. A particular point is therefore made of demonstrating to the boys the economic value of the herd by sale of surplus stock, milk and clarified butter.

All these practical operations are reinforced by theoretical instruction in classroom and there is no doubt that the senior boys fully understand the object and value of all the work. Evidence of this was shown recently when the whole school was put on to grass planting during a wet spell. The junior boys looked on it as a rather unpleasant fatigue, but the seniors fully grasped its importance and worked really well.

Finally it should be mentioned that the proximity of the Headquarters of the Veterinary Department with its laboratory, farms and experimental work, particularly on pasture, has provided the basis on which much of the school training rests and thanks are due to the ever-ready help given by officers of that department.

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A PRACTICAL POLICY FOR TSETSE RECLAMATION AND FIELD EXPERIMENT

PART II

By S. Napier Bax, Tsetse Research Station, Tanganyika Territory

THE PROGRESS OF THE LARGE-SCALE FIELD EXPERIMENTS—*Contd.*

The fire-exclusion and hardpan clearing experiment has continued over a period of nine years, but this is no criterion of the length of time the finished method, evolved from the experiment, would take to be effective. It cannot be insisted too strongly that what has been described is an experiment pure and simple. Ample time, allowing for a cycle of years unfavourable to the tsetse, when the population fell naturally (which might have been interpreted mistakenly as success for the experiment) had to be allowed. Then when the time came to clear the hardpans an effort was made to find the minimum of bush it was necessary to cut out and accordingly the measure could only be applied slowly. The aim must be to evolve a method which will reclaim land in three or four years. It is apposite to add that the nine-year fire-exclusion experiment has shown that almost the maximum effect that can be obtained from fire-exclusion is reached comparatively quickly, in the fourth year. Thereafter the effect increases but slowly. In practice, of course, clearing of the hardpans would be done *pari passu* with fire-exclusion, not after several years of fire-exclusion as was done in the experiment.

Two criticisms have been levelled against any reclamation measure, including fire-exclusion. The first is that it is impracticable and expensive to attempt to keep fire out of large areas. The second is that if the bush is permitted to thicken up, at the end of the reclamation period when the tsetse has gone, there will be a thicket area which is as useless to the inhabitants as was the bush when it contained tsetse. With regard to the first objection, it is certain that fire cannot be kept out of bush unless the local population is behind the measure. No attempt would be made to reclaim in this way without the support of the local population. With that support excellent results can be achieved, as is shown by the experience at Shinyanga in the early days when the people were land-hungry, and as is demonstrated to-day over an area of 250 square miles in Northern Rhodesia. Careful analysis of the bush at Shinyanga has shown that a single escape fire is by no means disastrous and does not throw the bush back to its state before protection; but the burnt-grass conditions favour the tsetse and so retard the progress of the experiment. With regard to cost, no estimate must be made on the elaborate organization which the Department maintains to-day to protect its almost irreplaceable experimental areas at Shinyanga. These valuable areas are obviously in a category by themselves. Rather must cost be calculated on total fire-exclusion in its early days at Shinyanga, though even those figures are much higher than should be possible in practical application of the measure. The labour cost for firebreaks and cost of patrols was then under six cents per acre per annum. In Northern Rhodesia to-day, the labour cost and cost of patrols work out at about four and a quarter cents per acre per annum.

Secondly, there is the question of the destruction of grazing by the thickening up of the bush. Even after nine years' protection the eluvial areas, and far less the alluvial, have not developed into pure thicket. There is still much grazing left. As the Department knows only too well, a fire will easily sweep through. Once reclamation had been completed, it is certain that, were the burning of the grass delayed annually for a month or two so as to obtain a strong burn, the bush would revert to its previous open nature in a few seasons.

The effect of fire-exclusion and clearing of certain drainage lines on G. morsitans.—Unfortunately the parallel experiment to the foregoing—fire-exclusion of typical long-grass Tanganyika *miombo*—was closed down owing to the war. However, at Abercorn in Northern Rhodesia there is a fire-exclusion experiment in *miombo*, though through higher rainfall conditions much of the area is unfortunately not typical of most of Tanganyika.

The Northern Rhodesian experiment has approximately followed the course of the Shinyanga one. Five years of fire-exclusion alone showed that this method by itself did not suffice to destroy *G. morsitans* everywhere in the area, though in certain long-grass valleys there was complete extermination of the tsetse concentrations and a tremendous reduction in other places. *Foci,* however, remained and they were found to be dependent on a certain type of narrow drainage valley fairly common in the

area—analogous in many respects to the Shinyanga hardpans. Most of the bush in these drainage lines has now been cut out and a great fall in numbers has followed. In 1941, when discriminative clearing operations had barely started, tsetses caught at the fly-pickets were reduced by 26 per cent compared with 1940; in 1942 there was a 63 per cent reduction on the 1941 picket figures; and in the first four months of 1943 there has been a 58 per cent reduction on the corresponding months for 1942. About one-half of one per cent of the area has been cleared to date. The control remains satisfactory. It still remains to be seen, however, whether the last tsetse will disappear. If the measures prove successful and were applied elsewhere, fire-exclusion and clearing of the hardpans would be introduced simultaneously and the time of reclamation much shortened.

The effect of merely clearing certain drainage lines or the hardpans on G. morsitans.—A parallel experiment to the one just described is very badly needed in typical Tanganyika *miombo* country.

From Northern Rhodesia there is evidence that the clearing of the special narrow type of valley which appears to support *G. morsitans foci* (see above), without fire-exclusion or organized burning, is effective in reducing greatly the number of tsetses. Whether the extermination point will be reached, urgently requires investigation. In some *miombo* country hardpan is found.

The effect of selective clearing on G. swynnertoni.—It is desired to draw an arbitrary distinction between the hitherto analogous terms "discriminative clearing" and "selective clearing" in order to describe two different methods of modifying the vegetational cover. Discriminative clearing will be applied to the removal of a definite vegetational type, which will of course be made up of a number of different species of trees. Hardpan clearing is described as discriminative clearing, i.e. the removal of the woody vegetation of the hardpans—vegetation which at Shinyanga ranges from the tall hard-wooded *Acacia rovumae* to the low very soft-wooded *Commiphora schimperi* and the thickety *Combretum parvifolium*. On the other hand, "selective clearing" will refer to the removal of certain species of trees right through the bush in whatsoever vegetation type they occur. The result of selective clearing is to reduce the bushed area to one or more species of trees—the species it has been determined to leave uncut. The trees that it will be decided to fell will, wherever possible, be the smaller and soft-wooded ones—those most easily removed.

The possibility of success in selective clearing lies in the need of the tsetse for a concurrence of vegetational types. There will be no such concurrence in selectively cleared country—the whole area will be reduced to one type.

Work on these lines has already been carried out, but it is too early yet to judge with what success. The method may produce a means of attack where hardpans are ill-defined, or where the whole area is of the hardpan type.

The effect of discriminative clearing of thickets on G. pallidipes.—*In* Acacia-Commiphora *savanna.*

An experiment of 3,700 acres is being carried out at Shinyanga to find out whether in the dry conditions prevailing it is necessary to fell all the thicket to rid the *Acacia-Commiphora* savanna of *G. pallidipes*. First the evergreen elements only were removed, but this failed to accomplish the object. All the riverine thickets have now been cut down, leaving the clean-stemmed trees, and it remains to be seen whether *G. pallidipes* will manage to exist in the extensive dry eluvial thickets.

A great deal more work should be done on *G. pallidipes*, and experiments started in areas representative of the main vegetational types of East Africa where this species lives. It may be found that *G. pallidipes* is more often merely a riverine or linear problem that superficial appearances would seem to indicate and that large areas infested by this tsetse are fed from the vital riverine thicket.

In Isoberlinia-Brachystegia-Acacia-Combretum *savanna.*—Under the moister conditions at Kingolwira in the Eastern Province, it is quite clear from the work that has been done on the riverine bush that *G. pallidipes* is not dependent merely on the riverine thickets, but also finds those on the eluvial ground perfectly suitable to its needs. Thicket clearing is now being extended to the general wooding in order to relieve the pressure on the farm. The fly-rounds will supply valuable information on the distance back from the cleared farm area it is necessary to remove the thickets.

Under coastal conditions.—An interesting, though small, practical experiment, which must be given a much fuller trial, was carried out by J. Y. Moggridge at Kilifi. The undergrowth

and tangled creepers were cut from 100 acres of the common coastal thicket to the point of permitting free walking and a reasonably open view, and a narrow barrier-clearing was placed around the area in an attempt to prevent infiltration of *G. pallidipes* from outside. The trash was carefully piled and burnt and it was hoped that a fair grass growth would follow. *G. pallidipes* in the treated area were reduced to 2.5 per hour, while outside in the general thicket the figure was 66. Odd tsetses were believed to be crossing the cleared barrier into the experimental area. The cost of "undercutting" came to Sh. 3/50 an acre and of piling and burning the trash to Sh. 2/50 an acre. Maintenance was calculated at Sh. 1 per acre per annum. It is not suggested that large areas of the unbroken coastal thicket should be reclaimed by these means, but that the extensive thicket clump country, which is at present barred to cattle, should be attacked. In such case the cost of an acre would be very much less than the Sh. 6 which is the cost of treating an acre of unbroken thicket. This work was unfortunately interrupted by the war.

Reclamation by shooting the game

Southern Rhodesia has shown that, where the bush is not too dense, country may be reclaimed from the savanna tsetse, *G. morsitans*, by shooting the game. As far as the writer knows, no distinction has been made between different species of game and its use as food to the tsetse—all game was shot.

The Tsetse Department had started a large-scale game experiment before the war, the intention being to make a preliminary study of the fauna, flora and distribution of tsetse and then to shoot out the game, species by species, commencing with the largest, at the same time carefully watching the results. Unfortunately the experiment had progressed no further than the preliminary stages when the war came and it had to be closed down.

This important experiment must certainly be revived at the end of the war. Shooting is a proved means of reclamation against *G. morsitans*. It certainly cannot be applied everywhere, owing to the topography of the country and the density of the bush, but it may well play an important part in reclamation in East Africa.

Defence

In the past defence against the savanna tsetses has been conceived in the form of a wide cleared barrier. It is plain that to-day there must be a different method, except in special circumstances which lend themselves to this measure. This is not because barriers have been proved to fail to stop tsetse. Unfortunately the author knows of no instance in which a cleared barrier has had a fair trial against an oncoming invasion of tsetse. Swynnerton clearly laid down that the barrier must be clean and that it must be wide; he doubted whether any barrier under two miles would be successful.

In Tanganyika the barrier has either been exceedingly dirty, that is, it has been so recently made that the trash was lying thick on the ground when the tsetse arrived, or it has not been two miles wide. Whether a barrier clearing as laid down by Swynnerton would be successful may now never be known, for the method has one great drawback. The fact that it is exceedingly expensive in man power is not fatal; in many areas the man power is available; but the regeneration that springs up on clearings of this nature entails an enormous annual tax of which the population soon tires. If settlement could be introduced thickly everywhere in the clearings, it would automatically deal with much of the regeneration, but over a great deal of the length, however carefully aligned with regard to water and good soil, the clearing makes no appeal to the people. Settlers naturally go for the "eyes" of the country, and only a comparatively small part of the whole length falls into this category.

Discriminative clearing, perhaps combined with fire-exclusion, may well provide the defence of the future. Suitable ground on which to hold the tsetse would be sought, that is, vegetation as unfavourable as possible to the species to be halted. Then it would be rendered still more unsuitable by the method of clearing discriminatively what favourable vegetational types there were. The "barrier" would be much wider than two miles—a kind of defence in depth—but the total area cleared would be a fraction of what a two-mile wide barrier would entail. This is merely a suggestion, but a suggestion based on observed facts. Work now in progress will give a lot more information on this important subject, but it requires the special study which was provided for by one of the Colonial Development schemes that was closed down on account of the war. After the war the question should certainly again receive special attention.

The Practical Application of the Known Methods of Reclamation and of those it is Hoped to Evolve from the Large-Scale Field Experiments

The known methods of reclamation and the large-scale, long-range experiments in progress, designed to produce suitable methods for attacking the great mass of the fly-bush having been shortly described, as well as experiments interrupted by the war and other experiments which new developments have shown should be tried out directly conditions permit, it remains to discuss the practical application of these methods on the grand scale. It helps not at all to devise methods which cannot be applied in practice.

First let the physical means to accomplish large-scale reclamation be considered. Even a very cheap method of reclamation—reclamation at perhaps a fraction of a man-day an acre—amounts up to a large total when great areas are involved. In some parts of East Africa the native population is dense, but in other parts it is very sparse indeed or non-existent. How are the latter areas to be tackled? It is thought that the answer lies in the high-powered diesel driven caterpillar tractor which is now built and which, with suitable attachments has proved itself capable of dealing with any kind of bush and of making firebreaks. This would enormously reduce man power requirements.

Now the actual fly-belts themselves must be considered, so that the size and kind of problem it is necessary to attack may be known. East Africa possesses several kinds of barriers to the tsetse—natural and artificial—which form the boundaries to the fly-bush, thus in effect breaking up the great mass of fly-bush into separate blocks, enormous in area though some of them may be. Reclamation of the great mass of the fly-bush will not be, therefore, a limitless task to which there is no finality. It would be undertaken block by block. Reclamation on this scale has an international aspect. Fly-belts do not end on a country's borders, but may extend for many miles into a neighbouring territory. In such cases co-operative effort would be essential. The great lakes of East Africa, and the smaller lakes too, form some of the most important natural boundaries. The seaboard is another. Areas of an altitude of over 6,000 feet like Iringa, Mbeya, Ufipa, Bukoba, Mbulu and other parts of the Northern Province, etc., are in Tanganyika generally free from tsetse and form natural barriers, though East Africa is not so favourably situated in this respect as countries more distant from the Equator. As the distance increases, so the altitude limit decreases (probably a temperature effect) until it is only about 4,000 feet in Southern Rhodesia. Great naturally open plains, of which there are many examples, like the Wembere in the Lake Province, form boundaries. In some places where two vegetational types meet, two species of tsetse, one the inhabitant of one type, the other of the second, meet and overlap to a certain degree. A tsetse map not differentiating between species of tsetse would correctly take no account of this, and show an unbroken belt of tsetse, but the expert will know that the change in vegetation forms as true a boundary as any of the foregoing. Finally the great cultivation steppes, like those in the Lake Province, form, if maintained, extremely valuable artificial barriers.

If the large-scale tsetse map of Tanganyika is examined it will be seen that the fly-bush towards the north is broken up into a number of separate or nearly separate blocks of comparatively small size, often by one or more of the barriers described above, while in the south it presents a much more solid appearance. Let the northern section—obviously the more simple—be considered first. With cheap and easily applied methods of reclamation available, how would the task of reclaiming the north be tackled? The island or "nearly island" blocks, of which there are at least seventeen, vary in size very approximately from areas of 300 square miles to those as large as 13,000, taking into account protrusions into Kenya. The smallest are perhaps double the size of the present experimental area at Shinyanga, but only half the size of a reclamation scheme which has recently been worked out for Arusha; the largest twenty times the size. Viewed in this light, the prospect of gradually extending reclamation to such blocks does not appear very formidable. Each block when won would stand alone; it would require no, or very minor, artificial props. The reclamation of one block would not depend on the reclamation of another, for each project would be self-contained. Obviously the larger blocks could only be reclaimed over a period of years. That is no innovation; it is what is being done at Ukerewe to-day. Operations would start at one end and be pushed along the length of the block, the flanks resting on tsetse-free country. As the work proceeded, so reclaimed areas of ever-increasing extent would become available for development in the rear; nearer the line of work there would be a buffer area in which operations had been completed, but which were not yet safe for utilization; then would

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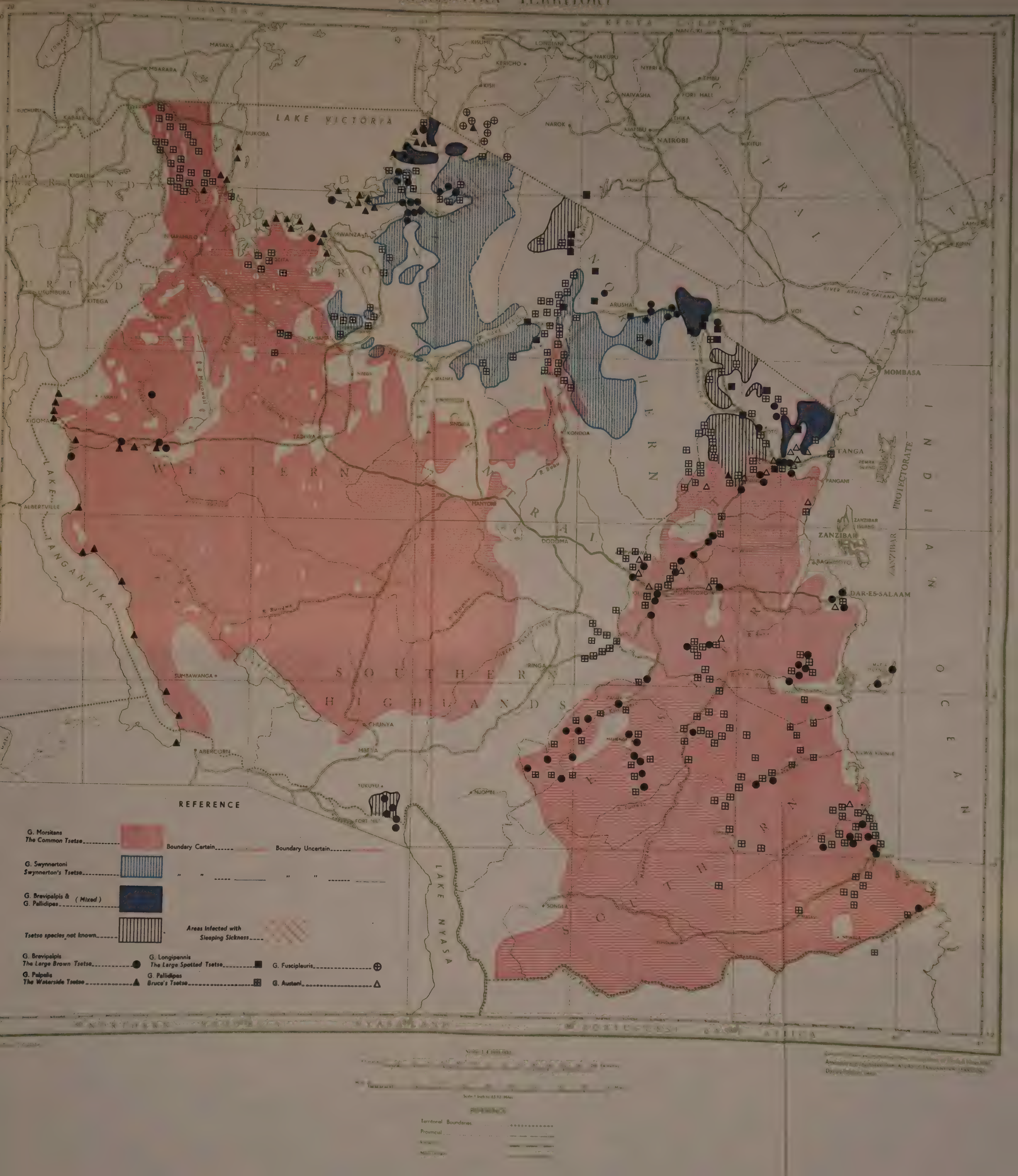
TANGANYIKA TERRITORY



come the battle-front, as it were, the place where active operations were in progress; and, beyond, the fly-bush yet to be treated. Interruption in the work of reclamation, though undesirable, would be by no means disastrous. If a pause were necessary, and some form of discriminative clearing were in use, all that would be required would be to see that no serious regeneration of bush took place in the buffer area.

Now it is in this northern area, which includes the economically important Lake and Northern Provinces, that there is the greatest scope for the application of the known methods of reclamation. Survey has already shown that hundreds of square miles can be reclaimed cheaply; there is little doubt that a complete survey would swell the hundreds to thousands of square miles amenable to present methods in these two provinces alone.

Let the southern and much larger area now be considered. The map shows that it is divided into eastern and western *G. morsitans* belt by the broad strip of tsetse-free country which runs approximately southwards from Dodoma to the head of Lake Nyasa. The western belt is very nearly a great island fly-belt, almost wholly confined to Tanganyika. Its north-west tip passes over the Uganda border, where it soon ends, and at the south-west at the southern end of Lake Tanganyika there is but a very narrow and tenuous connexion with the Abercorn belt of Northern Rhodesia. The eastern *G. morsitans* belt of Tanganyika is separated from all other belts in Tanganyika on three sides, but its southern border passes over into Portuguese East Africa on nearly a 400 mile front. How far this belt continues in Portuguese East Africa is uncertain. Even were cheap and easy means of reclamation available, how could these truly enormous areas of nearly 100,000 square miles each be tackled?

Firstly, it is not at all certain that these great *G. morsitans* belts are in fact so unbroken as they appear on the map; naturally it has only been possible to carry out a limited amount of survey in them as yet. Secondly, the fact has already been mentioned that the tsetse needs a concurrence of vegetational types. Over large areas the *Isoberlinia-Brachystegia* wooding runs on mile after mile practically unbroken by that change in vegetation to which drainage lines give rise. It has been found that unbroken *Isoberlinia-Brachystegia* carries very sparse tsetse indeed. This may prove highly important in supplying a natural defence line where a pause has to be made. Thirdly, and most important, Southern Rhodesia is already successfully facing a somewhat similar situation.

Southern Rhodesia has a northern *G. morsitans* tsetse front 475 miles in length (1941), of which 100 miles are protected by natural barriers. Active anti-tsetse measures—shooting of game—are being carried out over about 375 miles of this front. Now for comparison the maximum width of Tanganyika's "island" western *G. morsitans* belt is 330 miles, and in many places it is only 200 and less. The eastern belt is under 400 miles long on the Portuguese border, where it is at its widest. Further north it rapidly diminishes in width. Thus, if actual length of front is considered, it is seen that both the eastern and western *G. morsitans* belts of Tanganyika present fronts not longer than the *morsitans* front of Southern Rhodesia which is being more than successfully held to-day. But Southern Rhodesia has only 16,000 miles of tsetse-infested bush in front of her before she attains the comparatively safe line of the Zambesi river (it seems still uncertain whether she will attempt this or whether, instead of pushing forward, she will "freeze" her present line), while Tanganyika would have an area of approximately five times that in each of her great *morsitans* belts; and if a defence line were not to be set up on the Portuguese border the active co-operation of the Portuguese authorities would be required to deal with their part of the eastern belt. To sum up, while it is apparent that were an attempt made to destroy the Tanganyika *G. morsitans* belts, this country would face a much more difficult proposition than that Southern Rhodesia is now facing on her northern border, yet the scale of the successful Southern Rhodesian operations is so enormous that it gives confidence that with improved methods which research will bring, the Tanganyika problem might be tackled with equal success. The methods would, as far as can be seen to-day, follow that proposed for the northern tsetse islands, though the front would be much longer. A start would be made from one end and operations gradually pushed forward year by year, leaving reclaimed country in the rear. Reclamation of *miombo* country is not practical politics yet, nor reclamation on this scale; but it is by no means too early to examine future possibilities in the light of to-day's knowledge.

Note.—The map accompanying this article has been reproduced from the "Atlas of the Tanganyika Territory" by the Department of Land and Mines, Dar es Salaam.

(*To be continued*)

FEEDING VALUES OF STOVER FROM MAIZE, MILLET AND BULRUSH MILLET

By M. H. French, M.A., Ph.D., Veterinary Laboratory, Mpwapwa, Tanganyika Territory

The local grazings not only dry up but rapidly become eaten out as the dry season advances and it is a normal practice of native husbandry for the live stock then to be turned into the cultivated fields to feed on the crop residues left standing after the grain has been harvested. Crop residues and weeds therefore form a large bulk of reserve fodder and, since they become available at a time when natural grazings are becoming seriously depleted, play a very important part in the dietary of native live stock. It is clearly our duty to find out as much as possible about such a reserve of food so that the fullest and best possible use can be made of it. This article deals with the relative feeding values of the stovers left from the main cereal crops in this territory.

The term "stover" is used here to denote the dried stalks and leaves left in the field when the grain has been completely removed from maize, millet or bulrush-millet plants. Since the weight of stover is high in proportion to the weight of grain removed, it can readily be appreciated that a considerable proportion of the total nutrient material elaborated by these cereal plants is left behind in the stover when the grain has been harvested. The need for making the maximum use of these crop residues is an urgent husbandry problem in this territory and, as will be seen later, they possess much higher feeding values than is commonly supposed.

Owing to the native practice of turning the stock into the standing stovers a very considerable wastage of nutrients occurs through the trampling of the stover and its subsequent fouling by manure. To get the maximum value from these crop residues they should be cut or pulled after the grain harvest, stacked and later fed to the stock, preferably in racks. There is thus considerable scope for improvement in the method of using these residues, but little will be achieved until education in animal husbandry becomes more general. Throughout this article the emphasis is on the feeding value for stock, but the other important factor—manurial value—should not be neglected. Under existing methods all the crop residues which are not eaten, and thereby turned into an organic manure, are collected and burnt before the next season's cultivation commences. The ash value of these uneaten residues is retained by the area (in an unevenly distributed manner), but the humus fraction returned to the soil is very much less than if the whole of the stover passed through the live stock to be deposited as manure. Admittedly, the correct ultilization of his crop residues means a little more work for the native, but the greater return, in extra food for his stock and manure for his land, would repay many times over the extra effort in labour.

The stovers used in the following work were all obtained from local native-owned fields; they were cut off at ground level and stacked. Some of the leaves were very dry and some loss of leaf matter through shattering occurred, but this loss was kept as low as possible. The compositions of the stovers are given in Table I.

TABLE I

Compositions of Maize, Millet and Bulrush Millet Stovers

(Dry matter basis)

	Maize stover	Millet stover	Bulrush millet stover
Crude protein	4·99	4·30	4·29
Ether extract	1·11	1·25	0·86
N-free extract	52·50	46·99	41·93
Crude fibre	34·69	37·16	43·60
Total ash	6·71	10·30	9·32
SiO2	2·60	5·31	4·26
SiO2-free ash	4·11	4·99	5·06
Lime	0·529	0·587	0·694
Phosphate	0·508	0·680	0·516
Potash	1·196	1·205	1·468
Soda	0·659	0·645	0·656
Chlorine	0·229	0·278	0·250

These figures indicate that the local stovers contained less crude protein than the average of the American analyses given by Henry and Morrison (*Feeds and Feeding,* 19th Edition, 1928), namely 6.5 per cent for maize stover and 6.1 for kaffir corn stover. The local stovers also contained slightly less ether-soluble matter, but more fibre than the American samples. The mineral constituents are similar to those recorded elsewhere. In general composition, the stovers resemble hays from mixed local grasses, except that they contain less crude protein.

It appears that bulrush-millet stover is appreciably more fibrous than the other two types, but this would be expected from its hard, thinner stalks.

For determining the feeding values of the stovers they were chaffed to allow a more uniform mixture of leaves and stalks to be fed to each animal and so facilitate the work. The procedure adopted in each case was to feed adult native oxen chaffed hay of known digestibility each morning and to remove any uneaten hay at midday. The chaffed stover was then put in front of the animals and the uneaten portions removed the next morning. In the trials it was found that the more fibrous bulrush-millet stover was not less palatable than the mixed stover from ordinary red and white millets. The maize stover was eaten completely, but a considerable quantity of ordinary millet stover was left untouched, whilst with bulrush-millet stover much less remained uneaten.

The results of the digestion trials are summarized in Table II, together with the average digestibilities of American maize stover recorded by Henry and Morrison for 35 samples.

TABLE II

AVERAGE DIGESTIBILITY COEFFICENTS OF STOVERS

	Local maize stover	Local millet stover	Local bulrush-millet stover	American maize stover
Crude protein ..	49·30	30·45	12·88	37
Ether extract ..	70·68	89·26	45·26	62
N-free extract..	65·58	56·28	47·66	59
Crude fibre ..	70·80	61·97	57·24	66
Soluble ash ..	79·41	71·48	87·85	—
Organic matter..	66·69	57·14	50·65	—
Dry matter ..	67·22	57·58	53·42	57

The digestibility coefficients agreed fairly well for each pair of oxen, though the values for the crude protein fraction were somewhat divergent. The figures indicate that stovers contain crude protein of low digestibility and, though the local maize-stover protein was digested more efficiently than in the American trials, the local bulrush-millet stover contained protein of very poor digestibility. Maize and millet stovers gave fairly high coefficients for the digestibility of the ether extract, N-free extract and crude-fibre constituents, but the bulrush-millet stover gave lower values. It is considered that the highly fibrous nature of the latter stover is partly responsible for its lowered digestibility because the poorly digested extra fibre will impede the penetration of the digestive juices and hinder their action on the other constituents. The lowered digestibility coefficients suggest that the bulrush-millet stover contains a more lignified or woody fibre than the other two types. As would be expected from above, the organic and dry matters of bulrush-millet stover are less efficiently digested than in the maize and millet stovers, which compare well with the American figures.

The digestible nutrients and starch-equivalent values have been calculated, using Kellner's availability value of 47 per cent and are summarized in Table III.

TABLE III

DIGESTIBLE NUTRIENT AND STARCH EQUIVALENT VALUES OF STOVERS

(Per 100 parts SiO2-free dry matter)

	Local maize stover	Local millet stover	Local bulrush-millet stover	American maize stover
Digestible crude protein ..	2·46	1·31	0·55	2·40
Digestible ether extract ..	0·78	1·11	0·39	1·11
Digestible N-free extract ..	34·43	26·44	19·98	30·33
Digestible crude fibre	24·56	23·03	24·96	22·26
Digestible organic matter ..	62·23	51·89	45·88	56·10
Starch equivalent	29·51	24·82	21·71	26·78

The bulrush-millet stover has thus a lower starch-equivalent and much less digestible protein value than the other two types. Local maize stover compares well in feeding value with American stover, and ordinary millet stover has the same energy value but only half the quantity of digestible protein.

All stovers have a wide nutritive ratio owing to their relatively low contents of digestible protein. They are even poorer in this than the local hays from mixed grasses. In energy value, however, bulrush-millet stover compares with hay made at the end of the wet season from the full season's growth of grass. Maize stover has the same starch-equivalent value as aftermath hay made from the grass growth in the last four months of the rainy season. Millet stover has an intermediate energy value; but all stovers are superior in starch-equivalent value to the dried-up forage left standing on the grazing areas in the middle of the dry season. In addition, the maize and millet stovers contain more digestible protein than this dried-up herbage.

As it is at the season of dried-up and scanty grazings that the crop residues become available, it is easy to appreciate the great part they do, and could, play in tiding native-owned stock over the dry-season shortages. There is thus every reason for propaganda and education to teach the native the best ways of conserving and feeding his crop-residues so that the maximum benefit shall accrue to his live stock and his land.

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EAST COAST FEVER AND THE AFRICAN BUFFALO, THE ELAND AND THE BUSHBUCK

By E. Aneurin Lewis, B.Sc. (Agric.), M.Sc., Ph.D., Veterinary Research Laboratory, Kabete, Kenya Colony

The possibility of the occurrence of *Theileria parva*, the causal organism of east coast fever, in the game of countries in which the disease is indigenous was first raised by Ross (1911) in Kenya Colony. He found small parasites (piroplasms) in the red blood-corpuscles, and what he regarded as an undoubted Koch's blue body in a smear from the liver of a hartebeest (*Bubalis cokei*). Since that time similar parasites have been observed in the blood and other tissues of a large variety of game; and Koch's blue bodies have been discovered in smears from the spleen, the glands and the kidney of eland, and from the spleen of hartebeest, bushbuck and buffalo. The small parasites have usually been referred to as *T. mutans*, a piroplasm very much less virulent than *T. parva* and one that occurs commonly in the blood of healthy cattle in East Africa.

The presence of Koch's blue bodies, however rare, was at one time taken as a certain indication of east coast fever; and the discovery of such bodies in game suggested that at least some of these animals served as reservoirs of the east coast fever parasite. For many years it has been known to scientists engaged in the study of these parasites that Koch's bodies occur in the life-cycle of other species of *Theileria*. Theiler and Graf (1928) and other workers in South Africa found Koch's bodies in smears from cattle infected with *T. mutans* under conditions that eliminated any possible confusion with east coast fever. They have been demonstrated in outbreaks in which deaths have been confined to one beast or a very small number of cattle. They have frequently been reported from calves on farms associated with the occurrence of coccidiosis, chronic scours, paratyphoid, severe scalding as a result of dipping, malnutrition and worm infection; and they have been found in cattle exposed to mass tick infestation and other circumstances causing abnormal reaction to *T. mutans* infection. Koch's bodies have also been observed in smears from cattle in good slaughter condition and in cattle which have suffered, or died, from other diseases (De Kock *et al*, 1937). So the mere presence of Koch's bodies does not now necessarily imply the existence of east coast fever. These points are given full consideration in the identification of the parasites, and do not present serious difficulties in the present-day diagnosis of east coast fever in cattle.

The belief that game, especially the buffalo and the eland, maintain infection of east coast fever is based, not only on the isolated instances of Koch's bodies in smears, but also on evidence of a circumstantial character. For example, Richardson (1930) in Uganda moved a small herd of cattle from the Sese Islands, said to be free of east coast fever, to an area on the mainland where no cattle had been for two years, but where numerous buffaloes infested with the tick-vector (*Rhipicephalus appendiculatus*) of east coast fever had been grazing. About a month after arrival, a yearling beast died of east coast fever and the remaining animals contracted the disease one by one over a period of six weeks. Beaumont (1939) in Kenya described an outbreak of east coast fever four months after the discovery of small piroplasms and Koch's bodies in smears taken from a dead eland on a farm which was itself free from any known infection and surrounded by country where the disease did not appear to exist. Theiler (1928) stated it had definitely been proved that the Indian buffalo was susceptible to east coast fever; and since it was closely related to the African buffalo, the susceptibility of the latter must, in Theiler's opinion, be assumed.

On the other hand, wild animals as a factor in the maintenance of east coast fever infection have been considered to be of no consequence; and it was stated in 1926 (Wenyon) that there was no experimental evidence either for or against the view that the disease occurred in game; but experience up to that date appeared to indicate that in game country cattle are, if anything, less liable to east coast fever than in areas free from game.

Experimental evidence to demonstrate the extent to which game animals contribute to the maintenance and spread of the east coast fever parasite is not readily obtainable; and this very difficulty, supported by the facts that infected ticks lose the power of transmitting the disease after feeding on an immune animal, that the parasite disappears from the blood and other tissues of recovered animals, and that the

disease has not actually been diagnosed in game, strengthens the argument that the wild fauna do not constitute a serious source of infection. The identity of the small piroplasms and Koch's bodies in buffalo, eland and other species of game may be ascertained by inoculations of the blood of the infected animal into domesticated animals reared under tick-free conditions; and, as Daubney (1940) has pointed out, by the collection of engorged larvae or nymphae from the infected game and the transmission of the disease with these ticks to cattle under experimental conditions. The susceptibility to east coast fever of those game species commonly held responsible for outbreaks of the disease is not so difficult or complicated; and it is with reference to this aspect of the subject that experiments recently carried out with the African buffalo, eland and bushbuck at the Veterinary Research Laboratory, Kabete, may be of interest.

Four buffalo calves, two eland and one bushbuck captured at an early age and utilized in experiments on rinderpest were transferred to experiments on the transmission of east coast fever by ticks. When these animals arrived at the laboratory, they were infested with ticks of the species *R. pulchellus*, *R. simus*, *Boophilus annulatus decoloratus* and *Hyalomma* sp. The chief vector of the disease—*R. appendiculatus* (the common brown tick)—was not found on the animals. No small piroplasms were seen in smears examined for a few days before the experiments began.

Buffalo.—Batches of nymphal *R. appendiculatus* from lots proved to be infective by feeding on control oxen susceptible to east coast fever were put on the ears of two buffaloes. The ticks fed well. The buffaloes did not show a temperature reaction, nor were any parasites found in smears from the blood and the glands. In spite of the absence of clinical symptoms, it was conceivable that parasites, not demonstrable by microscopic examination of smears, might have been present in a latent or other form. Clean ticks were, therefore, fed on the buffaloes over the period during which a reaction occurs, and parasites appear, in infected cattle. In this way, it could also be shown whether or not the animals, presumably immune, could infect ticks, and thereby maintain and spread east coast fever. The ticks, thus fed, were allowed to moult and then put to feed on susceptible cattle. None of these cattle contracted east coast fever. It was, therefore, concluded that the buffaloes were definitely immune and incapable, under the circumstances, of infecting the clean ticks.

Another batch of the original infective ticks was fed on a third young buffalo, which showed an initial rise of temperature (102.2°F.) sixteen days after infestation. Following a further elevation (102.8°F.) on the seventeenth, the temperature began to drop; and by the twentieth day it had returned to normal (from about 99.0°F. to 101.0°F.). A single Koch's blue body was seen in a smear taken on the seventeenth day from a slightly swollen ear gland. On the next day another definite and several doubtful Koch's bodies appeared in the gland smears. Blood smears taken daily contained an extremely small number of piroplasms which continued to occur for many days after the buffalo had recovered from what appeared to be a mild attack of east coast fever.

Clean ticks with which this buffalo had been infested during the thermal reaction were, in the following instar, divided into lots and put to feed on four cattle. Three of these contracted typical east fever, and died. Postmortem examinations confirmed the clinical and microscopic diagnosis. The fourth failed to react, and was subsequently proved to be immune. A batch of clean ticks, fed on the buffalo during and after the fall of temperature did not transmit east coast fever when later they were fed on susceptible cattle.

It is evident from the results of this experiment that the African buffalo can be infected with east coast fever, and that *R. appendiculatus* fed on the animal during its reaction take up the infection and transmit the disease in a virulent form fatal to cattle. After recovery, the buffalo is not capable of infecting ticks with *T. parva*. The piroplasms in the blood smears during the thermal reaction were so rare that they could not be distinguished from *T. mutans*; but there is no doubt that those present in blood-corpuscles when the disease had subsided were not *T. parva*.

The mild form of east coast fever in the buffalo is of further interest in that it resembles, rather closely, the mild disease sometimes met with in cattle. The similarity as regards temperature reaction is illustrated by the accompanying charts. The difference in the incubation period is not significant. Koch's bodies in gland smears from the bovine were found only on the thirteenth day, and small piroplasms were, as in the buffalo, extremely rare in the blood. Piroplasms, of the *T. mutans* type, occurred a little more frequently after the temperature of the bovine had returned to normal. It is fairly certain that reactions of this nature would escape

notice under field conditions unless temperatures were regularly taken as a result of suspicion arising from the identification of Koch's bodies in smears taken from a few animals.

A batch of ticks which had fed on the buffalo during its reaction to east coast fever had been reserved for infesting the fourth buffalo in order to determine whether the passage of the parasite from buffalo through ticks to buffalo would enhance the virulence of the disease in the wild animal. This fourth buffalo failed to react, and when tested later with other ticks infected on a diseased ox, it proved to be immune.

time by experiment, it is shown that the African buffalo is sometimes susceptible to east coast fever and may be responsible for sporadic outbreaks of the disease.*

Attempts to transmit the disease to an eland and a bushbuck were unsuccessful.

Acknowledgments. — The writer acknowledges, with gratitude, the active part taken in the early stages of these experiments by Mr. W. Fotheringham, Senior Veterinary Research Officer; and the valuable assistance rendered throughout by Mr. A. J. Wiley, Junior Laboratory Assistant.

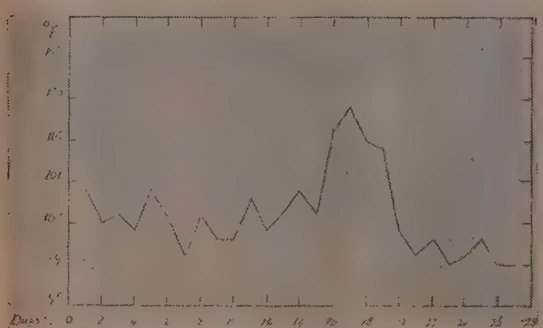

FIG. 1—Temperature of African buffalo—mild reaction to east coast fever.

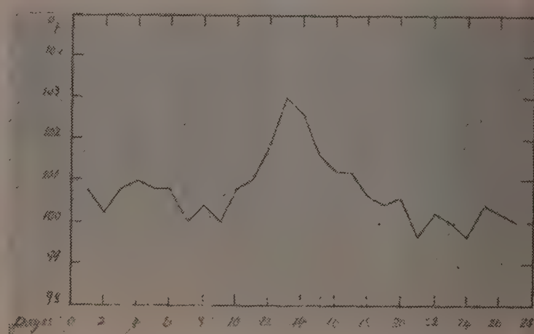

FIG. 2—Temperature of ox—mild reaction to east coast fever.

Eland and Bushbuck.—The same procedure adopted in the case of the buffaloes was carried out in testing the susceptibility to east coast fever of the young eland and the bushbuck. Neither of these animals showed any sign of infection as a result of infestation with known infective ticks; nor were they capable of transmitting the disease through ticks to cattle.

Summary.—Evidence in support of, and against, the possible maintenance and spread of east coast fever by game animals is briefly reviewed and discussed.

One out of four African buffaloes infested with ticks (*R. appendiculatus*) known to be infected with the east coast fever parasite contracted a mild form of the disease, and recovered. Clean ticks fed on this buffalo transmitted fatal east coast fever to cattle. The other three buffalo failed to react. Thus, for the first

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* These results introduce a further complication into the problem of E.C.F. eradication. They do not incriminate game to an extent that would justify indiscriminate slaughter: but they do emphasize the importance of tick control by dipping and other means.—*Ed.*

BUILDING WITH LIME

By H. O. Weller, B.Sc., M.Inst.C.E., Hon. A.R.I.B.A., Kenya

To build with portland cement is a simple affair; the material is so regular, in these days, and so patient of rough usage that the most unskilful workman can get results which will satisfy the immediate object of the building—till the final bills are passed for payment, shall we say.

To build with lime requires more skill and some knowledge of the materials being used; not, perhaps, to the extent of being able to burn lime, though that is a simpler undertaking than to burn cement clinker. The builder needs only to know the lime as he receives it, by type, characteristics and quality, and how best to make us of it.

Lump Lime.—In Britain, ordinary building limes are traditionally marketed as "lump" lime—i.e. unslaked lime as drawn from the kiln, of the same bulk as the original chalk or limestone it was burned from, transported not in bags but loose. In East Africa railways will only accept unslaked lime as "dangerous", in sealed containers. For long journeys these are reasonable conditions. On journeys short in time lump lime is not a dangerous load, nor does it deteriorate appreciably *en route*, for building purposes.

Lime burned in kilns or heaps is drawn as lump lime, however, so the way to deal with it should be mentioned for the help of prospective small-scale burners up-country. On receipt at site of building it should be slaked as soon as possible. During the slaking it swells up to two or three times its original bulk.

There are three ways of slaking lime, (*a*) to run it to a "putty", (*b*) to turn into a dry powder (hydrated lime), or (*c*) to mix it with its requisite proportion of sand, with water, and make a mortar rightaway.

Lime Putty.—The ideal slaking is to a putty, done in some pit or storage-bin. Water is added slowly. The lime gets hot, breaks down to a fine powder and finally to the consistency of cream. It should not be stirred. The lime will settle down to a dense material, set stiff: it will not harden. For use it is beaten down with spades or hammers, when it reverts to cream. More water must not be added; that is important. In this state of putty, lime may be kept, under a film of water or otherwise covered from evaporation, indefinitely; it was the rule in ancient Rome that lime so slaked must not be used for three years. One forgotten store of it, kept in sacks under the sea, was found after 500 years quite good. From this putty state the lime may be used, without sand, as the mortar-joint in ashlar stone masonry; the stones being so finely dressed that the joints can be only an eighth-inch thick. Also it is best so used as the plaster surface for fresco wall decorations. With added sand ordinary mortars and plasters are made; the mix being ground till gummy in a mortar-mill preferably, though this is not essential for ordinary work.

A quicker way to slake, to make a mortar rightaway, is to form a ring heap of the sand, pile the lump lime in the middle space and add the slaking water slowly. The sand is used to cool the slake, and finally to make the mortar. This mixed mortar may be kept indefinitely. It must be kept for a time if the work is to be sound, but this is not so important in mortar as in plaster. No additional water should be added when the mix is used. As picked up in the hod or *kerai* the mortar or plaster will be stiff, but it can be worked soft with the trowel. The Indian mason will usually try to make his work easier with gulps of water; the best prevention is to take away his little tin mug or water-can. He will probably then be convinced of the advisability of making sure that his stone or bricks are thoroughly soaked before use. They must be so full of water that they will not draw any from the mortar or plaster. This takes hours of soaking, steeped in water, not merely sprinkled.

Hydrated Lime.—For quicker use the lime may be slaked to a powder only, not to a putty. The lumps are heaped and water is sprinkled on them, carefully. The lumps swell, get hot, and fall to powder. The slaked lime is thrown onto rectangular sieves, propped just out of the vertical. The proportion of slaked lime which falls through may be considered good enough for ordinary plaster, or good mortar. It may be stored as a dry powder, kept from "air-slaking" as far as possible, in sacks or otherwise.

The proportion which does not pass the sieve may be sprinkled again, and so slaked; but it will usually be fit only for second-grade work.

This method of slaking is rough; it is done properly, however, at well-equipped modern kilns, where the lime is slaked with due precautions and the finest part of the powder—

the real hydrated lime, with no under-burned particles—is separated by air-lifting. The use of hydrated lime is becoming common in Britain, and is usual in East Africa, where it can be bought as readily as any other building material from a builders' merchant.

Hydrated lime can be run to a putty, for plaster, or used almost at once with sand for mortar. For plaster it *must* be run to a putty, and kept so—with or without its sand—till the mix is "soaked"; the time of maturing varies with the lime. A good "fat" (high-calcium) hydrated lime may be ready in 24 hours; it may take weeks. A magnesian lime takes two months.

Hydraulic Limes.—In East Africa there are deposits of limestone, as "kunker" and otherwise, which would burn to hydraulic limes if properly kilned. But there are no hydraulic limes on the market.

Small-scale lime-burning seems much more common in Tanganyika than in Kenya—see map in pocket of Bulletin No. 4 of the Tanganyika Geological Survey—and some of these locally-burned limes may be hydraulic. A typical kunker lime will not slake, and therefore cannot be run to a putty; it must be ground, and is stored and used like a portland cement. In ordinary mortars a kunker lime will not stand so much sand as a fat lime; some kunkers are so poor that they will stand no sand at all.

Several analyses of limes, and specifications for buying them, are given in the pamphlet "Building Lime", issued free by the Building Control Committee, Nairobi.

Sand.—For good sound results a good graded, sound and clean sand must be used. This is more important even than when portland cement is used. The commonest dirt in a sand is clay or loam, and a small proportion of this is of value in a cement mortar, except in floor surfaces or in ferro-concrete, making it easier to use with a trowel. With lime a dirty sand is not good for any purpose. The sand need not necessarily be a silica sand; a crushed rock is often as good, sometimes better as the rock may well have pozzuolanic properties—see Technical Pamphlet No. 8, East African Industrial Research and Development Board. The ideal sand is not necessarily "sharp", but all particles should pass though a sieve of 3/16th inch mesh, and none should be so fine as to pass through a No. 200 British standard sieve. Such fine particles are in fact silts. Some clean sands, such as blown sands, are so fine that they are useless in mortars.

If sea-sand must be used it should be dredged from the sea bottom; sand taken from the beach above low-water mark contains a high proportion of salt.

In regard to proportions of sand and lime, this varies with the quality of both; a few trials are worth while. With a hydrated lime as marketed in Kenya it is safe to start with 1 of lime to 4 of sand, by volumes.

Advantages of Lime Mortars.—It should be noted that in some parts of any building lime is actually better than portland cement. No cement should be used in building fireplaces, flues or chimney-stacks. Where exposure to fire is severe there should be no silica sand in the mortar, the best "sand" in such circumstances is crushed well-burned brick, or a crushed volcanic rock.

Lime mortars do not stain limestone walls. For this reason alone experienced English architects avoid the use of portland cement in such work wherever possible. The late Professor Lethaby, for example, never permitted portland cement in Westminster Abbey. One of the worst examples of cement-staining is that of the Cenotaph in Whitehall—ashlar work, where the use of anything but a lime-putty was indefensible.

Disadvantages of Lime-mortars.—A fat lime cannot be used in concrete, unless the sand has pozzuolanic value. Even the best pozzuo-lime cement could hardly be used in ferro-concrete. Lime makes a much better plaster for inside walls than portland cement does—it absorbs sound, it does not "sweat"—but white ants can creep up behind it, between the wall and the plaster, and so get into the woodwork of the roof. When a room is plastered with lime there must be an ant-stop perfectly secure, and the bottom 12 inches of the wall surface should be rendered with cement plaster.

Lime mortars set slowly and harden slowly. The set of a lime mortar joint is partly by carbonation from the surface inwards and partly colloidal. For the colloidal set it is obvious that the water proportion must be correct and that it should be released slowly; if these conditions are not present the joint in a thick wall will never set, except for the thin outer skin; years after, when such a wall may be broken down for alterations, the lime mortar will be merely a dry powder with no structural value other than against direct pressure.

Masonry or Brickwork Bridges.—When an ordinary arch is built with thick lime mortar

joints the centring must be held up by wedges, and these wedges must be lowered for an inch or two, depending on the span, after twenty-four hours. This is to settle the arch-rings into their strongest positions. Otherwise, when the arch takes the loads it was designed to carry, it will deform. If there is a long barrel to the arch the roof of it will sag in the middle. (The arch, however, will not crack as so many cement-built arches do.)

Dams, Bridge Abutments, Wing-walls and Retaining-walls.—These may be built in lime mortar, but they must be designed to resist overturning by their weight only: the resultant of the pressure and weight forces must keep within the "middle third" at all levels. Plain lime mortar must not be put into tension. Where bridge abutments, wing-walls and piers are subject to erosion by swift-flowing streams, the mortar-joints up to high flood-level should be in a pozzuolanic mortar, or the joints should be raked out an inch deep and pointed in cement. Failing a pozzuolana or cement-pointing, the mortar in these joints may be gauged with water in which rice has been boiled.

General.—There is no need to make walls thicker than usual when lime mortars are used instead of cement, but more care should be taken with the bond, in masonry or brickwork. Where concentrated loads come on a wall, such as the ends of girders or bressummers, large stones or bearing-plates should be used to distribute the pressure, or a few courses may be built in cement mortar. Where a roof, in domestic buildings, is so badly designed that it gives a thrust on the top of a wall, there should be a really effective wall-plate and it should be tied at corners with dragon-beams. In general, it may be said that when building in lime none of the traditional points of sound construction should be neglected, as they so often may be when building in portland cement.

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SUGGESTIONS ON HOW TO LOOK AFTER A HACK

By G. Baynes, Kenya

Take his temperature daily without fail. If you find it a degree over *his* normal (to be ascertained only by taking it daily for a fortnight) leave him in perfect quiet in his stable and give no hard corn until the temperature is normal.

Remember the old adage, "The foot's the horse", and keep his feet trimmed level with the rasp. Use the farrier's knife for other purposes. See that the native who calls himself a syce picks his feet out twice daily at any rate, and endeavour to teach him to always remove any droppings *at once* from the stable. Have his nostrils and dock wiped clean with a clean damp cloth every evening. The so-called syce invariably reverses the order of the wiping and uses the dirtiest rag he can find.

Feeding.—Six pound of sound crushed maize with two pound of bran, if available, with chopped lucerne, sweet potato tops or Napier grass mixed with the maize and bran and slightly damped is ample for a 15-hand horse, but he must have ample nice, sweet partially dried green grass or well-made hay. If you see him holding his head on one side and perhaps dropping bits out of his mouth while masticating his food, it is a sure sign his molar teeth want rasping and the sharp edges that form on the outside of the upper and inside of the lower molars in many horses want removing. Keep water always with him and salt too.

On the journey.—Dismount whenever you can. This permits the blood to re-enter the numerous blood vessels under the saddle. Let him drink on every possible opportunity on the journey and let him get his head down for a pick, too, whenever possible.

On arriving home, loosen the girths and leave the saddle on his back while the rest of him is done over. The so-called syce invariably whips the saddle off straightaway, a proceeding probably followed by inflamed lumps on the skin under the saddle. The more exhausted a horse is the less hard corn must he have; he simply cannot digest it. Molasses are a grand recuperative.

Essentials are constant care and attention to feet and teeth; a properly fitting saddle with a clean blanket under it; water, salt and sound roughage.

Take his temperature every morning without fail. If it is above normal leave him in his stable in perfect quiet.

The above, in italics, were Colonel Doherty's instructions in 1924 and have stood the test over the years since then. Everyone running a horse knows all these simple rules, but many omit to put them into practice. "The master's eye makes the horse fat" is most applicable in this land of Kenya.

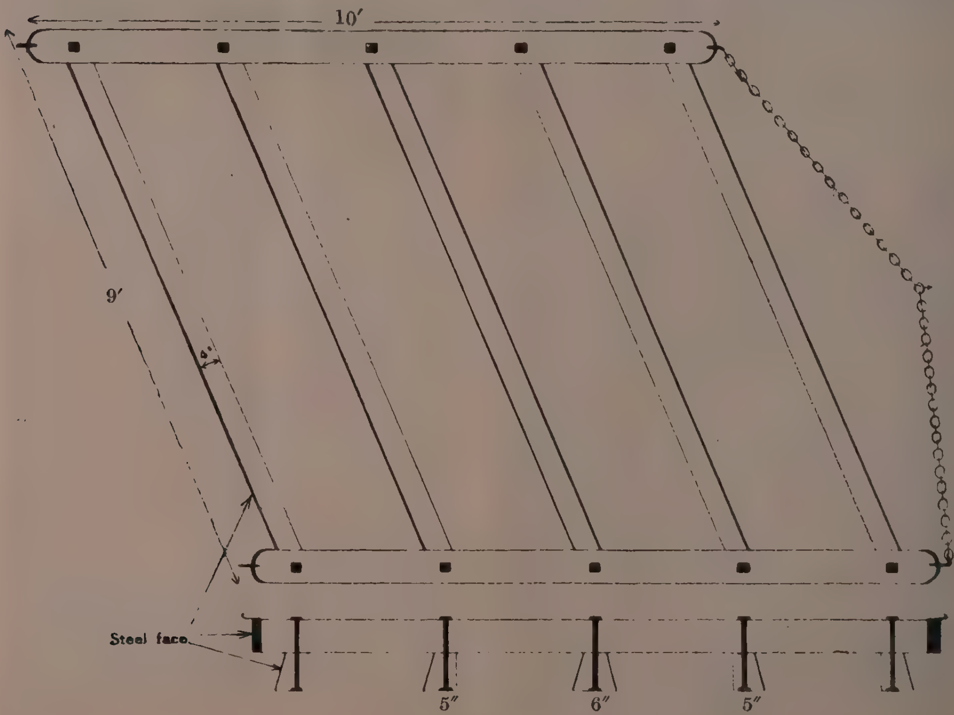
ROAD-MAKING ON HILLY FARMS OR PLANTATIONS

By A. G. G. Hill, B.A., B.Agr., B.Sc.

The construction and upkeep of the road systems needed on hilly farms or plantations where heavy timber haulage is a frequent operation, present a special and expensive problem, particularly if one depends on manual labour for road-making. One wattle farmer in Natal has solved this problem by mechanical means and claims to have made 300 miles of 9 ft. road on his extensive property, at remarkably little cost, using his own methods. Having studied these methods on several occasions in recent years I can vouch for their success and their comparatively low cost. The following is a brief description of them.

Five implements, hauled in turn by a span of 16 oxen, or a suitable tractor, are used in construction, i.e.: (1) a hillside plough, for opening up the soil, fitted with a share movable to right or left; (2) a pick-plough, for removing stones; (3) a Martin type ditcher (home-made for £5), for shifting loose soil; (4) a dam scoop, for filling in hollows; and (5) a wheel-less roadmaker or grader (home-made), the most useful implement of the lot. About a quarter of a mile of new road per day can be made with this outfit, plus six boys.

The route to be followed is first surveyed with an Abney level and pegged with a maximum grade of 1 in 12. Assuming that the new road is to be made on a hillside, the hillside plough is first put in and follows the line of pegs marking the middle of the future road, except on the steepest portions, when it should be kept a little above the line of pegs, otherwise later on the oxen will be hauling in excessively loose earth. Where the hillside is too steep for even the hillside plough, hand hoes may have to be used to make this first cut, but the land must be very steep indeed to make this necessary. After the return trip of the hillside plough the span is hitched to the pick-plough, which then removes most of the stones the hillside plough has failed to dislodge. The rest must be removed with crowbars or by blasting. The next operation is to put in the



ditcher, which, working like a one-sided snow-plough, pushes all the loose soil and stones to the lower side. During this operation the ditcher should be hitched so that its nose cuts into the upper side of the road all the time. The road should now be taking shape and appear as a shelf of varying width. After repeating the above operations three or four times this shelf should be wide enough to take the road-maker, or grader, which after approximately four runs puts the finishing touches on the job and leaves a fairly firm 9 ft. road. This very useful home-made grader, which weighs about a ton, is made in the form of a parallelogram, 9 ft. × 10 ft., its five steel-faced wooden cross-members being bolted to the two wooden side-members (see sketch). Hooks for the draught-chain are fitted at both ends of the side-members so that the grader can be worked in either direction without turning it. The angle at which the grader cuts the earth is altered by varying the position of the draught on the chain until the cross-members, which can pivot on their bolts, take up the required angle. This type of grader takes some knowing, but its tricks can be overcome by getting the draught right and by learning the use of skid poles, which must always be kept handy. When the grader chokes with earth and sods, as it sometimes does, these poles, which should be 12 ft. long and knot-less, are used to lever up the grader while in motion and so clear the blockage. By adjusting the draught so that the cross-members are at right-angles to the side pieces, the road-maker can be used instead of a dam-scoop for shifting loose earth into hollows or for making anti-erosion bolsters across roadways. It is necessary to tighten up the bolts periodically, otherwise the bolt-holes will enlarge. It will be found preferable to make the two wooden side-members 8 in. square, and not 5 in. as shown in the sketch, so as to give maximum support for the bolts.

This type of road-maker, once its ways have been mastered, is invaluable on a farm, not only for making new roads, but for the upkeep of those already existing. Four runs with it usually suffice to make a badly rutted 9 ft. road into a smooth track. Its chief merit, apart from its low cost, is its consolidating action which is lacking in the ordinary single-blade scraper running on wheels.

(*Received for publication on* 30*th June,* 1941)

SETTING THE BINDER FOR SHORT-STRAWED CROPS

H. O. C. Hunter, Tanganyika Southern Highlands Estates, Ltd., Iringa

Usually light short-strawed crops cause much trouble in cutting with a binder because the straw banks up on the knife bar and is not long enough to be caught by the canvas.

To overcome this a piece of flat galvanized iron sheeting is cut to fit just under the knife guards, which keep it in place in front, and is bent over the wooden lath on which the front end of the canvas runs. It is screwed to the inside of the lath with half-inch screws. This gives a smooth surface for the straw to slide over.

In order to push the short straw over this iron sheet, pieces of hide are screwed to the reel, one to each slat, so that about six inches of loose hide hangs down. The reel is set well back and low so that the hide just sweeps over the knife guards and brushes the short straw on to the canvas.

A side-drop sheaf-carrier is a useful attachment to any binder and for a short straw crop can have sacking fastened underneath, which will catch the loose grain and straw which drops out of the untidy bundles inevitable with these crops.

To ensure efficient cutting the knife sections must lie on the ledger plates of the guards, as the cutting action is like scissors. When the back of the guards wears, the sections are raised above the ledger plates, and however sharp the knife the cutting action is seriously interfered with. This is more noticeable with linseed, which is impossible to cut with a knife in this condition. If it is not very bad the guards can be knocked up with a hammer, but to take up any considerable play it is necessary to take off each finger or guard and put a shim between the guard and knife bar at the back of the bolt which holds the guard to the bar. Usually one or two thicknesses of petrol tin is sufficient. This just raises the point of the guard and enables the section to rest on the ledger plates.

These additional fittings can be left on the binder when cutting a normal crop as they do not interfere in any way.

SOME UGANDA VEGETABLES
PART II

By J. W. Purseglove, B.Sc., A.I.C.T.A., Agricultural Officer, Uganda Protectorate

Dioscorea triphyllum Linn. var. *dumetorum* (Kunth.) R. Kunth. Dioscoreaceae.

"Bitter Yam"; *Kamu* (Luganda); *Oruliga*, pl. *Ndiga* (Lunyoro).

A common wild twining plant with trifoliate leaves, tomentose on the under surface; petioles pubescent and prickly. This yam, which is only used in times of food shortage, contains a poisonous alkaloid, removed by slicing and steeping in water. The Banyoro steep it in streams or rivers for four days before cooking.

Dolichos debils Hochst. ex A. Rich. Papilionaceae.

Lagwathet (Karamojong).

A twining herb with trifoliate leaves and small pink flowers. Uncooked roots eaten in Karamoja (Thomas, unpub.).

Eriosema montana Bak.f. Papilionaceae.

Butengotengo (Luganda); *Omutenge* (Lunyankole).

A savannah herb, 2 to 3 ft. high, with hirsute trifoliate leaves and a compact inflorescence of small yellow flowers. The large tuberous roots are sometimes eaten in Ankole.

Gynandropsis gynandra Briq. Capparidaceae.

Akeyo (Acholi); *Ejobyo* (Luganda); *Esogi* (Lukiga and Lunyankole); *Eyobyo* (Lunyoro).

A common annual much-branched herbaceous weed up to 3 ft. in height; pedate, compound leaves; white or pinkish flowers and long capsules. It occurs wild, but is often seen cultivated near homesteads. The young shoots are commonly used as a pot-herd throughout East Africa. They are somewhat acrid in taste, owing to the presence of an oil similar to that of mustard. For this reason the sap is used as a counter-irritant for local pain, such as headache.

Hibiscus esculentus Linn. Malvaceae.

"Okra"; "Lady's Fingers".

A cultivated herb up to 5 ft. in height; large yellow flowers with purple centres. This exotic vegetable is widely grown by the Nilotic tribes of northern Uganda. The immature finger-like mucilaginous fruits are used as a soup vegetable, and the leaves, both fresh and sun-dried, as a pot-herb.

Hibiscus sabdariffa Linn. Malvaceae.

"Roselle"; *Ekiganga, Ekikenke* (Lunyoro).

The cultivated varieties of this species show great variation in form and size. In Bunyoro it is cultivated for its seeds, which are rich in oil. They are crushed and boiled in water to the consistency of a thin porridge, which is usually eaten as a sauce with the staple food.

Hyptis spicigera Lam. Labiatae.

Maniya (Lugbara).

An erect branched aromatic annual, 1–5 ft. high, with small white flowers. Cultivated in the West Nile District for its seeds, which are rich in oil, used in the same way as sim-sim, and often eaten with green vegetables.

Ipomoea batatas Poir. Convolvulaceae.

"Sweet Potato"; *Chok* (Acholi); *Ebitakuli* (Lunyoro); *Lumonde* (Luganda).

Sweet potatoes form the main root crop throughout Uganda, and are second in importance to the staple crops, finger millet or plantains, in all districts. They seldom feature in European diet despite the fact that they are very palatable when cooked correctly, roasted or boiled. During the present shortage of European potatoes increased use could be made of them.

The tubers are rich in diastase and may be regarded as a saccharine rather than as a starchy food. The 2–3.5 per cent protein is of high nutritive quality. The yellow-fleshed varieties are rich in vitamin A, and all contain vitamins B and C. The East African varieties are mostly white-fleshed and lacking in carotene.

The young leaves afford a readily available source of good green vegetables, and are used as such by most Africans. They are also valuable fodder for stock.

Lagenaria vulgaris Ser. Cucurbitaceae.

"Calabash gourd"; *Ekirio* (Luganda); *Endeku* (Lunyoro).

The common gourd, with white flowers and soft foliage, is cultivated in all tropical countries, and is mainly grown for the sake of the dried fruits. In Uganda the young fruits are eaten in times of food shortage.

Luffa cylindrica Roem. Cucurbitaceae.
"Loofah gourd"; *Kijumankuba* (Lunyoro); *Kyangwe* (Luganda).

An annual climber with yellow flowers; cultivated throughout the tropics. It is usually grown for the fibres of the dried fruit, which are used like a sponge, but the young fruits may be eaten and the leaves used as a pot-herb.

Lycopersicum esculentum Mill. Solanaceae.
"Tomato"; *Enyanya* (Luganda, Lunyoro); *Nyanya* (Acholi).

Tomatoes were grown extensively in Uganda before 1900 (Thomas, 1940). In native cultivation they are usually self-sown and receive little care. The commonest variety grown is *cerasiforme*. They are often cooked with the pot-herbs and included in the sauce eaten with the staple food.

Malva verticillata Linn. Malvaceae.

Orudega (Lunyaruanda); *Oruturuguma* (Lukiga).

A tall herb of high altitudes with large palmately-lobed leaves and clusters of small pink flowers in the leaf axils. The leaves are used as a pot-herb by the Bakiga of Kigezi District.

Manihot utilissima Pohl. Euphorbiaceae.

"Cassava"; *Ebiribwa* (Lukiga, Lunyankole); *Gwanda* (Acholi); *Muwogo* (Luganda); *Omuhogo* (Lunyoro).

Cassava, which is a native of Brazil, was probably introduced into Uganda at a comparatively late date by Arab traders. Its cultivation has been encouraged by the Government as it constitutes an excellent reserve against famine and locusts. Among some tribes it now forms a part of the normal diet, whereas among others only in times of food shortage.

The roots contain a cyanogenetic substance, which by enzyme action gives prussic acid, dissipated during cooking. In "sweet cassava" the poison is principally confined to the outer rind and so is removed during scraping, whereas in "bitter cassava" it is more evenly distributed throughout the root. As a source of ascorbic acid, the tubers are comparable with sweet potatoes.

Raymond *et al.* (1941) have shown that the leaves are a very valuable pot-herb, being one of the richest sources of vitamin C and they also contain appreciable amounts of carotene, losing neither of these substances on cooking, during which process the cyanogenetic glucosides are destroyed. They are also rich in calcium but contain oxalic acid. The leaves are commonly used as a pot-herb by the peoples of the East African coast. In Uganda they are not often eaten except in times of shortage, but in view of Raymond's findings every encouragement should be given to extend their use as a green vegetable.

Melothria maderaspatana Cogn.
Cucurbitaceae.

Nakasunsa (Lunyankole).

A tendril-climbing, annual herb with small yellow flowers. The leaves are sometimes used as a pot-herb by the Bakunta of western Ankole.

Musa paradisiaca Linn. Musaceae.

"Plantain"; *Ekitoke* (Luganda, Lunyoro).

Many varieties are recognized and they form the staple food in the wetter parts of the country, notably in Buganda and Toro. The fruits are always cooked, usually by steaming, before they are eaten. The root-stocks, *nkolo* (Luganda), *nkonya* (Lunyoro), are boiled and eaten in times of famine.

Musa sapientum Linn. Musaceae.

"Banana"; *Embire* (Lunyoro); *Mbide* (Luganda).

These are true "bananas" and are used almost entirely for making beer, but the fruits may be peeled, sliced and dried to form *mutere* (Luganda), a flour which constitutes a useful food reserve. The root-stocks are eaten in times of famine.

Musa spp. Musaceae.

"Wild Banana"; *Ekitembe* (Luganda, Lunyoro).

Several wild species of *Musa* occur in Uganda. The seeds are sometimes crushed to make a flour, and the root-stocks are eaten in times of food shortage.

Nymphaea spp. Nymphaeaceae.

"Water Lilies"; *Irebe* (Lunyoro).

Several species of *Nymphaea* grow in Uganda swamps and lakes, and the rhizomes are eaten in some parts of the country, particularly in times of famine. Thomas (1940) records that they are a fairly important item of diet in North Busoga. The fruit is also edible, as is that of *Trapa bispinosa* Roxb. (Water Chestnut), which when boiled has a pleasant, chestnut flavour.

Oxytenanthera abyssinica Munro. Gramineae.

"Bamboo"; *Koo* (Acholi); *Odra* (Lugbara).

The young shoots may be eaten in times of food shortage.

Phaseolus lunatus Linn. Papilionaceae.

"Lima Bean"; *Ebihimbi* (Lukiga, Lunyankole, Lunyoro); *Ebijanjalo* (Luganda); *Ebirangwa* (Lunyoro).

The types of beans grown by Uganda natives appear to be varieties of *P. lunatus,* and are the most important pulse crops in the country. The seeds are allowed to mature and dry before eating, although the green pods may be eaten as a vegetable. The leaves are an important pot-herb. They may be cooked, dried, powdered and stored until required. In this condition they are known as *gobu* (Luganda) and are mixed with cold water, simsim and salt and eaten as a sauce.

Phytolacca dodecandra L'Herit. Phytolaccaceae.

Oluwoko (Luganda); *Omuhoko* (Lukiga, Lunyankole, Lunyoro).

A common scandent shrub with alternate glabrous leaves, long spikes of small yellowish-green flowers and orange-red fruits. The plant is regarded by most natives as very poisonous, and a decoction made with the roots is used by suicides. The young shoots are sometimes cooked and eaten as a pot-herb in times of famine as in West Africa (Dalziel 1937). It is possible that if the young leaves contain a poisonous principle it is rendered inert during cooking as with cassava. This opinion is held by the natives, but until further information is available it is not advisable to use leaves as a pot-herb.

Portulaca oleracea Linn. Portulacaceae.

Bwanda (Luganda); *Obwanda* (Lunyankole, Lunyoro); *Tebere* (Acholi).

A prostrate annual weed with succulent branches and leaves; flowers yellow. Its use as a pot-herb has been recorded in Uganda, and it is regarded as antiscorbutic (Dalziel, 1937). Several cultivated varieties have been produced in Europe for use as vegetables.

Sechium edule Sw. Cucurbitaceae.

"Christophine"; *Kusulusuti* (Luganda).

The native cultivation of this introduced vegetable, the fruits of which are used like small vegetable marrows, is extending in some areas.

Sesamum angustifolium Engl. Pedaliaceae.

Echama (Karamojong); *Kiyonga* (Lunyoro); *Lutungotungo* (Luganda).

An indigenous herb with mauve flowers. It resembles sim-sim, but is never cultivated. The young shoots are used as a pot-herb in some parts of Uganda (Thomas, 1940).

Solanum (*anomalum* Thonn.) Solanaceae.

Buhuruhuru (Lunyoro); *Katumkuma* (Luganda); *Omutakarra* (Lukiga).

A tomentose undershrub with white or purple flowers; fruits bright red when ripe and $\frac{1}{3}$—$\frac{1}{2}$ in. in diameter. It is cultivated for the immature fruits. These may be cooked as a vegetable or made into sauce, and may be added to almost any vegetable dish.

Solanum incanum Linn. Solanaceae.

Enjagi (Lunyoro); *Entula* (Luganda); *Orutongo* (Lunyankole).

A variable tomentose undershrub up to 5 ft. in height, with white or purple flowers and fruits $\frac{3}{4}$ in. or more in diameter. The ripe fruits of a native cultivated form in Uganda are bright red. The immature fruits are used in the same way as *S. anomalum* described above and are very commonly used for seasoning vegetable dishes. They may be cooked fresh or dried, which is done by threading them on string and drying slowly in the shade.

Solanum nodiflorum Jacq. Solanaceae.

Enswiga (Lunyoro); *Eshwiga* (Lukiga, Lunyankole); *Nsuga* (Luganda).

A common glabrous weed, 1 to 3 ft. in height, with small white flowers; berries about $\frac{1}{4}$ in. in diameter, black when ripe. It is sometimes cultivated. A common native pot-herb throughout East Africa. The young shoots make an excellent substitute for European spinach. Occasionally they are rather bitter and the addition of a little sugar improves the flavour.

Solanum sp. (P. 1203). Solanaceae.

Obugora, Obugorora (Lunyoro); *Nakasuga* (Luganda).

A herb up to 2 ft. in height with lobulate, usually glabrous, leaves, small white flowers and small berries, turning red when ripe. It is cultivated for its leaves, which are widely used in Uganda as a pot-herb.

Vigna angustifolia Hook.f. Papilionaceae.

Maruet (Karamojong).

A twining herb with small trifoliate leaves and greenish flowers. Thomas (unpub.) has recorded that the swollen fusiform roots are eaten in Karamoja.

Vigna monophylla Taub. Papilionaceae.

Emisino ye mpungu (Lunyankole).

A herb up to 1½ ft. with simple glabrous leaves and a terminal closely-crowded inflorescence of small green flowers. The swollen root-stock is occasionally eaten by the Banyankole.

Vigna ungiculata Walp. Papilionaceae.

"Cowpea"; *Enkole* (Lukiga, Lunyankole); *Enkole nyamugobe* (Lunyoro).

Cowpea, which is one of the few crops of African origin, is grown in most parts of Uganda. It is an important article of food in the Eastern Province, particularly in Teso District. The grain is usually eaten as a dry pulse which may be either roasted or boiled. The leaves form one of the most important and widely used pot-herbs of the Protectorate, and are preferred by most tribes to all other leafy vegetables. They are often rolled and dried and may be kept in this state for as long as three months before being used.

Vigna sp. (P. 1285). Papilionaceae.

Kiindira (Luganda); *Omugabe iswa* (Lunyoro).

A twining legume with glabrous trifoliate leaves, fairly large purplish flowers, and long cylindrical pods. The leaves and pods are eaten as a pot-herb in Bunyoro District.

Urtica massaica Mildbr. Urticaceae.

Egyisura (Lunyaruanda); *Ekicuraganyi* (Lukiga).

A "nettle" up to 6 ft. high with stinging hairs on the stem and the cordate leaves and with axillary spikes of minute green flowers. The young leaves are used as a pot-herb by the Bakiga of Kigezi District.

It is interesting to note that the common nettle (*U. dioica* Linn.), which is a very old English pot-herb, is being increasingly used in England as a green vegetable during the present war.

Xanthosoma sagittifolium Schott. Araceae.

"Tannier".

The Uganda vernacular names are the same as those for *Colocasia antiquorum*. The two plants resemble each other, but *Xanthosoma* has a more erect habit and sagittate, lighter green leaves. It requires a wetter habitat than *Colocasia* and is usually planted in the swamps. The tubers are eaten, but not the leaves.

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STORING SWEET POTATOES*

Farmers are aware that sweet potatoes rot very rapidly after being dug (especially in the hot weather). The following experiment indicates a method of preserving them indefinitely.

About 50 lb. weight was put in a drum on 17th July, 1942, with alternate layers of fresh wood ash. Monthly tests indicated that they were keeping well. The drum was finally tipped out on 27th November and only two or three small potatoes were found to be decomposed.

As illustrating "That there is nothing new under the sun", a Northern native assistant informed me that his people frequently dug sweet potatoes in August—dug a hole in the ground, put in a layer of sand, then filled the hole with alternate layers of potatoes and wood ash, finally covering with earth. He claimed that they kept in good condition until the following February.

W. B. Blyth in *Rhodesia Agricultural Journal.*

* For another method see this *Journal 8* (2) p. 73 (October, 1942)

HOST LIST OF THE PARASITIC FUNGI OF UGANDA
PART III

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SOLANACEAE

CAPSICUM ANNUUM
Glomerella cingulata (Stonem.) Spauld. & Schrenk.
Colletotrichum nigrum E. & H.
Vermicularia Capsici Syd.
Gloeosporium piperatum Ell. & Ev.
Rhizoctonia bataticola (Taub.) Butl.
Schlerotium Rolfsii Sacc.
Alternaria tenuis Bolle.

DATURA sp.
Alternaria crassa (Sacc.) Rands.
Alternaria Solani (Ell. & Mart.) Jones & Grout.

LYCOPERSICUM
Septoria Lycopersici Speg.
Cladosporium fulvum Cooke.
Alternaria Solani (Ell. & Mart.) Jones & Grout.
Cercospora sp.
Verticillium Dahliae Kleb.
Rhizoctonia Solani Kuhn.
Rhizoctonia bataticola (Taub.) Butl.

NICOTIANA TABACUM
Pythium sp.
Erysiphe cichoracearum DC.
Cercospora Nicotianae Ell. & Ev.
Alternaria longipes (Ell. & Ev.) Mason.
Alternaria tenuis Bolle.
Bacillus Aroideae Townsend.
Bacterium angulatum Fromme & Murray.
Rhizoctonia bataticola (Taub.) Butl.

PETUNIA sp.
Cercospora sp.

PHYSALIS PERUVIANA
Entyloma australe Speg.
Cercospora rigospora Atk.
Rhizoctonia bataticola (Taub.) Butl.

SOLANUM MELONGENA
Cladosporium fulvum Cooke.
Alternaria Solani (Ell. & Mart.) Jones & Grout.
Cercospora melongenae Welles.
Verticillium Dahliae Kleb.
Fusarium sp.

SOLANUM TUBEROSUM
Actinomyces scabies (Thaxt.) Gussow.
Colletotrichum tabificum Pethybr.
Alternaria Solani (Ell. & Mart.) Jones & Grout.
Verticillium Dahliae Kleb.
Cercospora concors (Casp.) Sacc.
Rhizoctonia Solani Kuhn.
Rhizoctonia bataticola (Taub.) Butl.
Phytophthora infestans De Bary.
B. phytphthorus Appel.
B. solanacearum E. F. Sm.

SOLANUM (Wild spp.)
Oidium sp.
Schiffnerula sp. (? "*Asterina solani-torvi* Hansf.").
Aecidium sp. (*A. habungense* P. Henn. ?).
Aecidium sp. (*A. Solani-unguiculati* P. Henn. ?).
Colletotrichum Lycopersici Chester.
Cercospora concors (Casp.) Sacc.
Cercospora Solani Thuem.
Cercospora nigri Tharp.

CONVOLVULACEAE

ASTROCHLAENA sp.
Aecidium Astrochlaenae Wakef. & Hansf., ined.

IPOMOEA BATATAS
Pythium sp.
Rhizoctonia bataticola (Taub.) Butl.
Fusarium spp.

IPOMOEA (Wild spp.)
Cystopus Ipomoeae-pes-caprae Cif.
Meliola clavulata Wint.
Meliola malacotricha Speg.
Asterina sp.
Uromyces Ipomoeae Berk.
Puccinia holosericea Cooke.
Coleosporium Ipomoeae (Schw.) Burr.
Ascochyta sp.
Alternaria sp.
Cercospora sp.
Aecidium sp.

LEPISTEMON sp.
Meliola Lepistemi Hansford.

STICTOCARDIA sp.
Meliola malacotricha Speg.
Aecidium sp.

Indet. Hosts
Meliola clavulata Wint.
Puccinia holosericea Cooke.

SCROPHULARIACEAE

ALECTRA sp.
Cercospora Alectrae Hansford.

SCOPARIA sp.
Aecidium Scopariae Wakef. & Hansf., ined.

BIGNONIACEAE

KIGELIA sp.
Meliola bidentata Cooke.

MARKHAMIA PLATYCALYX
Elsinoe sp.
Irenina sp.
Meliola Markhamiae Hansf. & Stev.
Meliola kampalense Hansf. & Stev.
Meliola lanceolata-setosa Syd.
Uredopeltis congensis P. Henn. (?)
Uredo sp.
Cercospora leprosa Syd. (incl. "*C. Dolichandrones* Hansf.").
Helicobasidium longisporum Wakef.

SPATHODEA sp.
Armillaria mellea (Vahl) Fries.

STEREOSPERMUM sp.
Elsinoe sp.

PEDALINEAE

SESAMUM spp.
Gloeosporium macrophomoides Sacc.
Alternaria macrospora Zimm.
Cercospora Sesami Zimm.
Cylindrosporium Sesami Hansford.
Helminthosporium sesameum Sacc.
Fusarium oxysporum Schlecht., f.
Verticillium Dahliae Kleb.
Rhizoctonia bataticola (Taub.) Butl.
Macrophomina Phaseoli (Maubl.) Ashby.
Cercospora Gratiolae Ell. & Ev.

ACANTHACEAE

ACANTHUS sp.
Aecidium Acanthi A. L. Sm.
Brachysporium Acanthi Hansford.

BARLERIA sp.
Asterina tertia Rac. var. *africana* Doidge.

DYSCHORISTE sp.
Oidium sp.

HYPOESTES sp.
Uredo Hypoestes (Cooke) De Toni.

JUSTICIA sp.
Plasmopara Willdemanniana P. Henn.
Irenina irregularis Stev.
Meliola Justiciae Hansford.
Meliola Psychotriae Earle (?).
Leptodothiorella advena Syd.

Aecidium acanthacearum Cooke.
Aecidium Justiciae P. Henn.
Asterina tertia Rac. var. *africana* Doidge.
Phyllosticta sp.

MIMULOPSIS sp.
Irenina irregularis Stev.
Meliola Psychotriae Earle (?).

SCLEROCHITON sp.
Meliola Schlerochitonis Hansford.

THUNBERGIA sp.
Meliola Thunbergiae Hansford.
Puccinia Thunbergiae-alatae P. Henn.
Cercosporella Thunbergiae Hansford.

WHITFIELDIA sp.
Schiffnerula Whitfieldiae Hansford.
Asterina fimbriata Kalchbr. & Cooke.

VERBENACEAE

CLERODENDRON spp.
Meliola clerodendricola P. Henn.
Meliola Clerodendri Hansford.
Meliola sakawensis P. Henn. var. *acutiseta* Hansford.
Asterina clerodendricola Hansford.
Asterina entebbeensis Hansford.
Euryachora sp. (?).
Physalospora Clerodendri Syd.
Uredo convestita Syd.
Aecidium sp.
Chrysomyxa sp.

GMELINA sp.
Helminthosporium sp.

LANTANA sp.
Meliola sakawensis P. Henn.
Meliola sakawensis P. Henn., var. *major* Hansford.
Puccinia natalensis Diet. & Syd.
Puccinia natalensis Diet. & Syd., var. *Evansii* Doidge.
Cladosporium herbarum Lk. f.

LIPPIA spp.
Puccinia accedens Syd.
Puccinia lippivora Syd.
Aecidium Evansii.
Meliola sakawensis P. Henn.
Cercospora Lippiae Ell. & Ev.

VERBENA sp.
Helminthosporium sp.

VITEX sp.
Meliola clerodendricola P. Henn. var. *Viticis* Hansford.
Schiffnerula Viticis Hansford.
Chaetothyrium sp.
Phaeosaccardinula sp.
Olivea scitula Syd.

LABIATAE

ACHYROSPERMUM sp.
Meliola Pycnostachydis Hansford.

COLEUS sp.
Irenina glabra (B. & C.) Stevens.
Irene inermis (Kalchbr. & Cooke) Theiss. & Syd., var. *minor* Hansf. & Stev.
Meliola Psychotriae Earle (?).

GENIOSPORUM sp.
Aecidium Geniospori Wakef. & Hansf., ined.
Asterina Geniospori Hansford.

HOSLUNDIA sp.
Meliola microspora Pat. & Gaill.
Eutypella sp.
Puccinia Hoslundiae Grove.

HYPTIS sp.
Irene inermis var. *minor* Hansf. & Stevens.
Uredo sp. (? *Puccinia Hyptidis*).

LEONOTIS sp.
Puccinia leonotidicola P. Henn.
Oidium sp.
Phoma sp.

LEUCAS sp.
Puccinia leucadis Syd.

MENTHA sp.
Puccinia Menthae Pers.

MICROMERIA sp.
Uredo sp.

OCIMUM sp.
Peronospora Lamii A. Br.
Meliola Psychotriae Earle (?).
Uromyces Ocimi Hansford, ined.
Puccinia Ocimi Doidge.

POGOSTEMON CABLIN
Pythium sp.

PYCNOSTACHYS
Aecidium Pycnostachydis Kalchbr.
Meliola Pycnostachydis Hansford.

MONOCOTYLEDONES

COMMELINACEAE

ANEILEMA sp.
Uromyces pretoriensis Doidge.

COMMELINA sp.
Uromyces Commelinae Cooke.
Zythia nectriola Speg. (?).

BROMELIACEAE

ANANAS sp.
Peronospora sp.
Phyllosticta sp.
Thielaviopsis paradoxa (De Seynes) v. Hoehnel.

MUSACEAE

MUSA sp.
Glomerella cingulata (Stonem.) Spauld. & Schrenk.
Marasmius semiustus B. & C.
Gloeosporium musarum Cke. & Mass.
Thielaviopsis paradoxa (De Seynes) v. Hoehnel.
Pestallozzia sp.
Zygosporium oscheoides Berk.
Helminthosporium Musae-sapientum Hansf.
Helminthosporium torulosum (Syd.) Ashby.
Cercospora Musae Zimm.

ZINGIBERACEAE

AFRAMOMUM sp.
Gibberidea zingiberacearum Rac.
Puccinia Aframomi (Har. & Pat.) Hansford, ined.

COSTUS sp.
Irenopsis Chandleri Hansford.

ELETTARIA CARDAMOMUM
Cercospora sp.
Zygosporium oscheoides Berk.

CANNACEAE

CANNA sp.
Fusarium sporotrichioides Sherb.

MARANTACEAE

MARANTOCHLOA sp.
Meliola Marantochloae Hansford.

LILIACEAE

ALLIUM CEPA
Puccinia Allii Rud.

ALOE sp.
Uromyces Aloes (Cooke) Magn.
Phoma aloicola Trinch.
Phyllosticta sp.
Pestalozzia Aloes Trinch.
(*Montagnella maxima* Mass., Kenya.).

ASPARAGUS sp.
Puccinia Asparagi DC.

GLORIOSA sp.
Colletotrichum sp.
Cercospora Gloriosae Syd.

ORNITHOGALUM sp.
Ustilago Peglerae Bub. & Syd.

PHORMIUM TENAX
Pestalozzia sp.
Heterosporium sp.
Mycosphaerella sp.

SMILACACEAE

SMILAX KRAUSSIANA
Puccinia kraussiana Cooke.

ARACEAE

AMORPHOPHALLUS sp.
Cercospora Chevalieri Sacc.

ARISAEMA sp.
Cercospora Arisaemae Tai.

TYPHACEAE

TYPHA sp.
Stagonospora Typhae v. Hoehnel.

IRIDACEAE

DIERAMA sp.
Puccinia Dieramae Syd.

GLADIOLUS QUARTINIANUS
Uromyces Gladioli P. Henn.
Uromyces transversalis (Thum.) Wint.
Alternaria tenuis Bolle, f.
Fusarium sporotrichioides Sherb.

DIOSCOREACEAE

DIOSCOREA sp.
Amazonia dioscoreae Hansf. & Stev.
Asterina sp.
Hemileia Dioscoreae-aculeatae Rac.
Uredo Dioscoreae P. Henn.
Uredo Dioscoreae-sativae Syd.
Phyllosticta sp.
Cercospora contraria Syd.
Mycosphaerella contraria Hansf.
Cercospora Dioscoreae Ell. & Mart.

AGAVACEAE

AGAVE SISALANA
Colletotrichum Agaves Cav.

DRACAENA sp.
Meliola dracaenicola Pat. & Har.
Meliola dracaenicola Pat. & Har., var. *major* Hansford.
Phyllosticta sp.
Cercospora Dracaenae Hansford.

SANSEVIERIA sp.
Meliola Sansevieriae Wakef.

PALMAE

CARYOTA URENS
Spaeromema fimbriata (E. & H.) Sacc.

PHOENIX sp.
Meliola palmicola Wint.
Gibbera guaranitica Speg.
Lophiostoma juliis var. *Phoenicis* Roll.
Phyllachora sp.
Graphiola Phoenicis (Moug.) Poit.

RAPHIA sp.
Meliola palmicola Wint.

PANDANACEAE

PANDANUS sp.
Pestalozzia sp.

HYPOXIDACEAE

HYPOXIS sp.
Uromyces Hypoxidis Cooke.

ORCHIDACEAE

VANILLA PLANIFOLIA
Colletotrichum sp.

JUNCACEAE

LUZULA sp.
Puccinia obscura Schroet.

CYPERACEAE

CAREX sp.
Farysia olivacea (DC.) Syd.

CYPERUS sp.
Meliola circinans Earle.
Uredo cypericola P. Henn.

FIMBRISTYLIS sp.
Puccinia fimbristylidis Arth.
Cintractia axicola (Berk.) Cornu.

JUNCELLUS sp.
Puccinia (*Bulbostylidis* Doidge ?).

KYLLINGA sp.
Uredo Kyllingae P. Henn.
Helminthosporium Kyllingae Hansford.

MARISCUS spp.
Phyllachora cyperina P. Henn.
Phyllachora sp.
Puccinia hennopsiana Doidge.
Cintractia axicola (Berk.) Cornu.
Cintractia limitata Clint.
Piricularia grisea Sacc. f.
Cercospora ugandensis Hansf.

SCLERIA sp.
Puccinia sp.

GRAMINEAE

AGROSTIS sp.
Uredo of *Puccinia Agrostidis* Plowr.

ANDROPOGAN sp.
Uromyces Clignyi Pat. & Har.
Uredo (of *Puccinia erythraeensis* Pazschke ?).
Sphacelotheca Andropogonis (Opiz.) Bubak.
Fusarium graminearum Schwabe.
Gibberella Saubinetii (Mont.) Sacc.

ARISTIDA sp.
Puccinia Bottomleyae Doidge (incl. *P. lomellii* Wakef. & Hansf. ined.).

ARTHRAXON sp.
Uredo arthraxonis-ciliaris P. Henn.
Puccinia erythraeensis Pazschke.

BECKEROPSIS sp.
Cercosporella Beckeropsidis Hansford.
Phyllachora sp.
Periconia sp.

BOTHRIOCHLOA sp.
Puccinia Amphilophidis Doidge.
Curvularia geniculata (Tracy & Earle) Boedijn.

BRACHIARIA sp.
Uromyces leptodermus Syd.
Diorchidium Brachiariae Hansford, ined.
Helminthosporium sp.
Cercospora sp.
Beniowskia sphaeroidea (Cooke) Mason.
Fusarium paspalicola P. Henn.
Phyllachora sanguinolenta Syd.
? *Phaeodothis stenostoma* (Ell. & Tr.) Theiss. & Syd.
? *Sphacelia* sp. (always attacked by *Cerebella*).

BROMUS sp.
Uredo sp.

CENCHRUS sp.
Uredo sp.
? *Sphacelia* sp. (always covered with *Cerebella*).

CHLORIS sp.
Phyllachora chlorodicola Speg.
Uromyces Chloridis Doidge.
Puccinia Chloridis Speg.
Uredo sp.
Periconia lateralis Ell. & Ev.
Helminthosporium sp.
? *Sphacelia* sp. (always attacked by *Cerebella* or by *Fusarium paspalicola*).

CTENIUM sp.
Uredo Ctenii Wakef. & Hansf., ined.

CYMBOPOGON sp.
Phyllachora sp.
Puccinia erythraeensis Pazschke.
Puccinia Cymbopogonis Massee.
Puccinia Amphilophidis Doidge.
Sphacelotheca Andropogonis (Opiz.) Bubak.
Colletotrichum graminicolum (Ces.) Wils.
Polythrincium sp.
Helminthosporium sp.

CYNODON sp.
Phyllachora Cynodontis (Sacc.) Niessl.
Puccinia Cynodontis Desm.
Ustilago Cynodontis P. Henn.
Helminthosporium Cynodontis Marign.

Periconia lateralis Ell. & Ev.
? *Sphacelia* sp. (Attacked by *Cerebella*).
Fusarium paspalicola P. Henn.
Fusarium moniliforme Sheld.

DACTYLOCTENIUM sp.
Puccinia Dactyloctenii Wakef. & Hansf., ined.

DIGITARIA sp.
Claviceps Digitariae Hansford.
Phyllachora digitaricola Doidge.
Ustilago Rabenhorstiana Kuhn.
Uromyces Peglerae Pole Evans.
Puccinia Digitariae Pole Evans.
Sphacelotheca dolichosora Ainsw.
Piricularia grisea Sacc., f.
Piricularia Oryzae Cav.
Helminthosporium sp.
Cercospora Setariae Atk.

ECHINOCHLOA sp.
Phyllachora sp.
Cercospora sp.

ELEUSINE sp.
Phyllachora Eleusines Speg.
Cylindrosporium sp.
Piricularia Oryzae Cav.
Helminthosporium leucostylum Drechs.
Helminthosporium (*nodulosum* B. & C. ?).
Sclerotium Rolfsii Sacc.
Gibberella Saubinetii (Mont.) Sacc.

ENTEROPOGON sp.
Septoria sp.

ERAGROSTIS sp.
Phyllachora sp.
Uromyces Eragrostidis Tracy.
Puccinia Eragrostidis Petch (?).
Helminthosporium Ravenelii Curt.

EXOTHECA
Puccinia erythraeensis Pazschke (*Uredo Exothecae* W. & H., ined.).
Hendersonia crastophila Sacc., f.

FESTUCA sp.
Uredo sp.

HELICTROTRICHON sp.
Uredo sp.

HETEROPOGON
Puccinia erythraeensis Pazschke.

HYPARRHENIA sp.
Didymosphaeria sp.
Leptosphaeria Hyparrheniae Hansford.
Ophiobolus implexum (E. & E.) Berl.
Lophiostoma Hyparrheniae Hansford.
Sphacelotheca congensis (Syd.) Wakef.
Sorosporium Tembuti Ev. & Henn.
Sorosporium Hansfordii Ainsw.
Hendersonia Sacchari Speg., f.
Curvularia Hyparrheniae Hansford.
Tetraploa aristata B. & Br.
Cercospora sp.
? *Sphacelia* sp. (Always attacked by *Cerebella*).

IMPERATA sp.
Puccinia rufipes Diet.
Sphacelotheca Schweinfurthiana (Thuem.) Sacc.
Monacrosporium sp. (?).

ISCHAEMUM sp.
Phyllachora Liebenbergii Hansford.

LEERSIA sp.
Leptosphaeria Leersiae Pass.
Tolyposporium globuligerum (B. & Br.) Ricker.
Neohoehnelia oligotricha (Mont.) Theiss. & Syd.

LEPTOCHLOA sp.
Phyllachora Cynodontis (Sacc.) Niessl.
Uromyces Leptochloae Wakef.

LOUDETIA sp.
Ustilago Trichopterygis Massee.

MELINIS sp.
Uredo Melinidis Kern (?).
Phyllachora melinicola Syd.

MICROCHLOA sp.
Uromyces Microchloae Syd.

MISCANTHIDIUM sp.
Phyllachora sp.
Uredo sp.

OLYRA sp.
Neohoehnelia oligotricha (Mont.) Theiss. & Syd.
Puccinia deformata B. & C.
Meliola substenospora v. Hoehnel.

ORYZA SATIVA
Leptosphaeria Iwamotii Miyake.
Leptosphaeria Michotii (West.) Sacc.
Ophiobolus miyabeanus Ito & Kurib.
Gibberella Saubinetii (Mont.) Sacc.
Phoma glumarum Ell. & Tracy.
Piricularia Oryzae Cav.
Helminthosporium Oryzae Miyake.
Fusarium graminearum Schwabe.
Epicoccum neglectum Desm.
Graphium stilboideum Corda.
Melanospora Zamiae Corda.
Nigrospora Oryzae (B. & Br.) Petch.
Fusarium moniliforme Sheld.

PANICUM sp.
Phyllachora graminis (Pers.) Fuckel.
Phyllachora heterospora P. Henn.
Uromyces leptodermus Syd.
Uromyces sp.
Tilletia Ayresii Berk. ex Mass.
Ustilago ugandensis P. Henn.
Piricularia grisea Sacc., f.
Helminthosporium Panici van Overeem.
Spegazzinia ornata Zimm.
Fusarium paspalicola P. Henn.
Fusarium moniliforme Sheld.
Rhizophagus sp.

PASPALUM sp.
Uredo Paspali-scrobiculati Syd.
Sphacelotheca sp.

PENNISETUM sp.
Trichosphaeria bambusina v. Hoehnel.
Didymosphaeria Panici March. & Stey.
Leptosphaeria Penniseti Hansf.
Ophioceras bambusae v. Hoehnel.
Puccinia Penniseti Zimm.
Uredo sp.
Ustilago kamerunensis Syd.
Tolyposporium Penicillariae Bref.
Phyllachora Penniseti Syd.
Sclerospora graminicola (Sacc.) Schroet.
Sphacelia sp.
Chaetostroma atrum Sacc.
Pestalozzia sp.
Coniosporium inquinans Dur. & Mont. (?).
Helminthosporium sp.
Tetraploa aristata B. & Br.
Speira toruloides Corda.
Piricularia grisea Sacc., f.
Xenosporella Berkeleyi Sacc.
Beniowskia sphaeroidea (Cooke) Mason.
Hypocline Penniseti Syd.

PEROTIS sp.
Helminthosporium sp.

PHALARIS sp.
Uredo sp.

PHRAGMITES sp.
Papularia sphaerosperma (Pers.) v. Hoehn.

POA sp.
Uredo sp.

RHYNCHELYTRUM
Phyllachora Tricholaenae P. Henn.
Diorchidium Tricholaenae Syd.
Piricularia grisae Sacc., f.

ROTTBOELLIA sp.
Puccinia Rottboelliae Syd.
Cercospora fusimaculans Atk.

SACCHARUM sp.
Leptosphaeria Sacchari Breda d. Haan.
Leptosphaeria saccharicola.
Marasmius Sacchari Wakker.
Papularia vinosa (B. & C.) Mason.
Melanconium Sacchari Massee.
Nigrospora Oryzae (B. & Br.) Petch.
Curvularia lunatum (Wakker) Boedijn.
Helminthosporium Sacchari Butl.
Stigmella Sacchari Speg.
Cercospora longipes Butl.
Cercospora Kopkei Krug.
Colletotrichum falcatum Went.
Sclerotium Rolfsii Sacc.
Thielaviopsis paradoxa (de Seynes) v. Hoehn.
Fusarium moniliforme Sheld.

SCHIZACHRYIUM sp.
Epichloe Schumanniana P. Henn.

SETARIA sp.
Sclerospora graminicola (Sacc.) Schroet.
Phyllachora Evansii Syd.
Phyllachora sp.
Puccinia Cameliae Arth.
Puccinia spp.
Uromyces sp.
Tilletia echinosperma Ainsw.
Helminthosporium sp.
Piricularia grisea Sacc., f.
Hendersonia Setariae Hansford.
Fusarium paspalicola P. Henn.
Fusarium moniliforme Sheld.
Uromyces Setariae-italicae (Diet.) Yosh.

SORGHUM sp.
Sclerospora graminicola (Sacc.) Schroet.
Sclerospora Sorghi (Kulk.) Weston & Uppal.
Puccinia purpurea Cooke.
Sphacelotheca Sorghi æLink) Clint.
Sorosporium reilianum (Kuhn) McAlpine.
Sphacelotheca cruenta (Kuhn) Pott.
Tolyposporium Ehrenbergii (Kuhn) Pat.
Phoma insidiosa Tassi.
Colletotrichum graminicolum (Ces.) Wils.
Nigrospora sphaerica Sacc.
Helminthosporium turcicum Pass.
Stigmella maydicum (Sacc.) Mason.
Alternaria tenuis Bolle, f.
Cercospora Kopkei Krug. (?).
Cercospora Sorghi Ell. & Ev.
Curvularia lunata (Wakker) Boedijn.
Chaetostroma atrum Sacc.
Fusarium paspalicola P. Henn.
Fusarium moniliforme Sheld.
Fusarium graminearum Schwabe.
Gibberella Saubinetii (Mont.) Sacc.
Rhizoctonia bataticola (Taub.) Butl.
? *Sphacelia* sp. (Always parasitized by *Cerebella*).

SPOROBOLUS sp.
Phyllachora afra Syd.
Uromyces tenuicutis McAlp.
Puccinia sp.
Helminthosporium Ravenelii Curt.

STREBLOCHAETE
Uredo sp.

THEMEDA sp.
Uredo Anthistiriae-tremulae Petch.
Puccinia versicolor Diet. & Holw.
Sorosporium Holstei P. Henn.

TRAGUS sp.
Uromyces Tragi Hansford, ined.

TRICHOPTERYX
Leptosphaeria Trichopterygis Hansford.
Epichloe cinerea B. & Br.
Puccinia erythraeensis Pazschke.
Puccinia Trichopterygis Wakef. & Hansf., ined.
Tetraploa aristata B. & Br.
Meliola Panici Earle.

TRITICUM SATIVUM
Leptosphaeria Tritici (Garov.) Pass.
Ophiobolus sativus (P. K. & B.) Ito & Kurib.
Gibberella Saubinetii (Mont.) Sacc.
Puccinia glumarum (Schm.) Erikss. & Henn.
Puccinia graminis Pers.
Puccinia triticina Erikss.
Ustilago Tritici (Pers.) Jens.
Helminthosporium sorokinianum Sacc.
Fusarium graminearum Schwabe.

UROCHLOA sp.
Uromyces leptodermus Syd.

ZEA MAYS
Sclerospora graminicola (Sacc.) Schroet.
Ophiobolus sativus (P. K. & B.) Ito & Kurib.
Gibberella Saubinetii (Mont.) Sacc.
Gibberella fujikuroi (Saw.) Wollenw. var. *subglutinans*. Edw.
Puccinia Maydis Bereng. (*P. Sorghi* Schw.).
Nigrospora Oryzae (B. & Br.) Petch.
Nigrospora sphaerica Sacc.
Helminthosporium Sorokinianum Sacc.
Helminthosporium turcicum Pass.
Fusarium graminearum Schwabe.
Fusarium moniliforme Sheld. var. *subglutinans*. Wollenw.
Fusarium semitectum B. & Rav.
Rhizoctonia bataticola (Taub.) Butl.
Cercospora Sorghi Ell. & Ev.
Colletotrichum graminicolum (Ces.) Wils.]
Stigmella maydicum (Sacc.) Mason.

FUNGI PARASITIC ON ANIMALS

NEMATODES
Myzocytium vermicolum (Zopf) Fischer.

INSECTS
Empusa Gryllii on locusts.
Empusa Aphidis on aphids.
Empusa Muscae on house flies.
Entomophthora sphaerorperma Fres. on flies, *Dysdercus*, etc.
Penicillium brevicaule Sacc. pm *Dysdercus*.
Myriangium Duriaei Mont. & Berk. on scales.
Nectria coccophila (Desm.) Wollenw. & Reinking on scales.
Nectria Tuberculariae Petch on scales.
Torrubiella alba Petch on spiders.
Podonectria coccicola (Ell. & Ev.) Petch on scales.
Cordyceps bicephala Berk. on ants.
Cordyceps dipterogena B. & Br. on flies.
Cordyceps Lloydii Fawcett on ants.
Cordyceps nutans Pat. on Pentatomids.
Cordyceps tuberculata (Lev.) Maire on butterflies.
Cordyceps typhulaeformis B. & C. on pupae.
Hypocrella javanica (Penz. & Sacc.) Petch on scales.
Hypocrella Raciborskii Zimm. on scales.
Hypocrella sp. on Aleyrodids.
Aschersonia Coffeae P. Henn. on scales.
Aschersonia placenta B. & Br. on scales.
Aschersonia crenulata Pat. Har. on scales.
Aschersonia Zenkeri P. Henn. on scales.
Cephalosporium Lecanii Zimm. on scales and Aleyrodids.
Beauveria Bassiana (Bals.) Vuill. on *Stephanoderes*.
Spicaria sp. on scales.
Torula sp. on *Dysdercus*.
Hirsutella floccosa Speare.
Hirsutella citriformis Speare on *Habrochila placida*.
Hirsutella sp. on scales.
Isaria Sphingum Schw. on moths.
Gibbelula aranearum (Schw.) Syd. on spider.
Tubercularia coccicola Stev. on scales.
Tetracrium coccicola v. Hoehnel on scales.

PHYSICAL RESEARCH ON PROBLEMS OF SOIL CULTIVATION*

By B. A. Keen

Dr. Keen's article challenges many traditional ideas about agricultural methods. In particular, he brings evidence to show that, contrary to deeply ingrained tradition, crop yields are remarkably insensitive to variations in cultivation; and that the attractive "capillary tube" theory of the movement of soil moisture is entirely untenable. The work described is likely to have far-reaching effects upon agricultural thought.

When the scientist first seriously turned his attention to agriculture he was confronted with traditions—true, partly true and false. The beginnings of agricultural science were to a considerable extent concerned with the examination of these traditions, with the separation of truth from falsehood, and with their restatement in scientific terms. Agricultural science is a young growth, for although the literature shows that, almost from the beginnings of scientific inquiry, attention was given to agriculture, such attentions were in the nature of incursions. The present-day agricultural research laboratories, staffed by chemists, biologists, physicists, and even mathematicians, are, with rare exceptions, the product of the past fifty years. The physicist was a late arrival to this team. It is true that a century ago Schübler, in Germany, worked almost exclusively on the physical properties of soil and that, in Britain, Sir Humphrey Davy's *Elements of Agricultural Chemistry* balanced his somewhat backward notions of soil chemistry by stressing the importance of soil physics; but before those pioneer works could be followed up the brilliant researches and field experiments of Lawes and Gilbert at Rothamsted, which overthrew the much-advertised ideas of Liebig on plant nutrition, had brought soil chemistry and biology to a position where a complete theory of soil fertility seemed within easy grasp. Soil physics fell into the background and remained there until the latter part of the nineteenth century. Its re-emergence was due largely to United States workers: especially Hilgard in California and King in Wisconsin. In the climatic and soil conditions of America the remarkably swift spread of arable agriculture over that continent had thrown up urgent soil problems. Hilgard was specially concerned with irrigation and soil-alkali problems, and King, working under higher but still insufficient rainfall conditions, made important practical studies on the effects of tillage operations on the moisture content of the soil. In the more settled agricultural conditions of Europe there was a less striking but steady revival of interest in soil physics, marked by the appearance, over the years 1878-98, of a German journal, edited by Wollny, devoted entirely to original articles on the physical properties of soils and plants and on argicultural meteorology. At the end of the nineteenth century soil physics had become a recognized branch of agricultural science. Warington, at Rothamsted, summarized the existing knowledge in an excellent little book, *The Physical Properties of Soil*. But the subject was outgrowing its existing theoretical framework. The time was ripe not only for a critical re-examination of the framework by competent physicists, but for its extension to include a study of the colloidal properties shown by all finely divided materials. In Great Britain the subject was reopened at Rothamsted in 1913. Much attention has been given to field and laboratory studies of the laws of moisture-movement in the soil and to their practical bearing on tillage operations and crop growth. Alongside this work, long-range researches on the physical and physico-chemical properties of clay were made, because in the vast majority of soils this finely divided material has a controlling influence on soil properties and behaviour.

Generalizations have grown up in soil physics, often based on simple experimental procedure, the results of which seemed to give a qualitative but plausible grouping of various soils into classes. The need for some such specification was as evident then as now, but it resulted in the appearance of many soil "constants" and "equilibrium points": most were empirical, some were spurious, others contained not one but a complex of factors, and yet others depended on the subjective judgment of the experimenter. Part of the task of the modern soil physicist is to explore this collection and to reject, amend, or replace.

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These so-called soil constants and equilibrium points fall into one or other of two classes. In one class, the soil and water are kneaded into a paste, and some property is measured on the sample: it may be the force for rupture of the dry block, the volume shrinkage of the block on drying, the lowest moisture content at which the sample can be rolled out without cracking, the moisture content at which it is just becoming sticky, or the moisture content at which the paste begins to flow when tilted. Measurements of this kind were developed and extensively used by Atterberg in Sweden in a system of soil classification, and they are of the kind that would naturally be used by agricultural engineers interested in the behaviour of soil towards cultivation implements of various types and designs.

In the second class the soil is used in its natural loose field condition (or in an analogous state of packing), when its pore space will be about 25 to 50 per cent, depending on the type of soil. This class of measurement attempts to specify the behaviour of the soil in natural conditions by a series of moisture contents corresponding to a series of prescribed environmental conditions. It is unnecessary to mention in detail the many measurements proposed and used. Some had their origin in attempts to make an agricultural classification of soil types; others were devised in efforts to give some numerical specification of practical observations on soil conditions in relation to plant growth and the effects of cultivation operations.

During the period 1900-25 the development of these soil "constants", and the discovery of simple relationships between them, had a fascination for many soil investigators. It was, however, a dangerous occupation, especially for those who did not realize that the ease of making a particular measurement, and the straightforward reproducibility of the numerical result, were no guarantee that the figure expressed any real and simple physical property of the soil. Again, the existence of simple cross-relationships between two or more so-called independent constants was no proof that these constants had a simple physical interpretation. Part of the trouble was that investigators took over from their predecessors without serious question the early theory of soil-moisture movement, based on the "capillary tube" hypothesis. The theory was simple and attractive, and required no deep physical training for its understanding. Soil was porous, so the pore space could surely be regarded as a bundle of capillary tubes in which water would distribute itself in accordance with the simple concepts of surface tension and capillarity. It was admitted that the tubes must be irregular in cross-section, but it was convenient to assume that that could produce only minor discrepancies.

The essential feature of the phenomenon of capillarity is that the narrower the tube the greater is the height to which water will rise in it. At one stroke, therefore, the observed difference between drought-prone, coarse-grained, or sandy soils and drought-resisting, fine-grained, or clayey ones was explained. In the latter the capillary tubes were much narrower; they could draw up water from the underground water-table through much greater distances than sandy soils could. The traditional belief that hoeing conserved soil moisture had an equally facile explanation: hoeing disrupted the upper inch of the fine capillary tubes and produced a loose mulch with large pore spaces into which the water could not rise and be lost by evaporation. The agricultural operation of rolling young crops had also a simple explanation: the roll compressed the top soil round the young roots so that the narrower capillary tubes thus produced could draw water from the wider ones below for the benefit of the plant. It only remained for some numerical value to be put on the maximum effective height of capillary rise in typical soils and the practical demonstration of the theory would be complete. Laboratory and field experiments, however, showed rises of only 2 to 3 ft., instead of the confident predictions of 10 ft., 30 ft., or more—yet the theory still bore a charmed life.

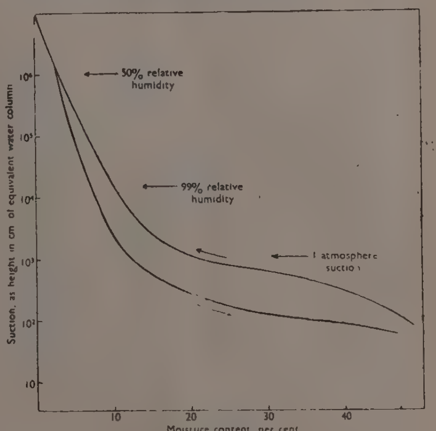
The first hint that all was not well with it can be found in a paper, *The Dynamics of Soil Moisture*, written by Briggs in America as long ago as 1897. But he omitted an apparently unimportant step in developing his argument —a step which over thirty years later was recognized by Haines at Rothamsted as the key to the problem. In 1917 Versluys in Holland reopened the subject on lines which were correct although obscurely expressed. Later, at Rothamsted, Haines and then Schofield worked out the correct theory of moisture movement in soil and confirmed it experimentally. Haines showed that the pore space in soil was essentially of a cellular nature, consisting of relatively large voids communicating

with one another through relatively narrow necks. The moisture distributes itself in curved films within these cells and necks in accordance with the physical principle that it tends to reduce its free surface, and hence its surface energy, to a minimum. The pressure under a curved water meniscus is less than outside, and the greater the curvature the greater is the pressure deficiency. The pressure deficiency therefore, is a suction force which controls the filling or emptying of the cells.

The manner in which filling or emptying occurs can be seen by taking a simple case. Let a cell and its necks be full of water and suppose evaporation is taking place at one of the necks. The water level in this neck will retreat steadily, until the meniscus reaches the narrowest cross-section of the neck. Here the equilibrium becomes unstable, because further retreat of the meniscus carries it into a wider cross-section where a smaller pressure deficiency than the one already built up would be adequate to maintain equilibrium. Hence expansion into the cell takes place abruptly, or, in other words, air suddenly enters the cell and a portion of the water is displaced to new positions.

Similarly, when the moisture content is increasing from dryness to saturation, once the thickness and curvature of the water film lining the cell and necks attain a certain value, instability sets in. The films in one or more of the necks suddenly close; the stability of the air bubble in the cell is upset and the cell becomes full of water. One salient feature of the moisture relations is, therefore, the quantumlike movements of water associated with filling and evacuation of the cells. But there is another important consequence of the theory: the opening and the collapse of a neck (and the emptying and filling of a cell) do not occur at the same pressure deficiency. There is no unique relation between pressure deficiency and moisture content. The relationship between them shows a marked hysteresis loop. Hence regions of high and low moisture content can exist in equilibrium together. Haines demonstrated the truth of this by simple and ingenious experiments.

Haines' treatment of the problem is specially applicable to coarse, sandy soils. Schofield's later contributions produced a generalized physical theory based on energy relationships. Because it deals with energy relationships, this treatment has a great advantage: it is applicable to all soils and holds whatever the mechanism at work. Schofield expresses the differences in suction forces as free energy differences, which can be defined as the height in centimetres of the water column needed to give the suction in question. A logarithmic scale is used because of the wide range of this factor. Thus when the moist soil is in equilibrium with an atmosphere of 50 per cent relative humidity ("air-dry" soil) the equivalent water column would be about 10 km. high, or higher than Mount Everest. By wetting and drying soils against suction and by using results for soil vapour pressures and freezing point depressions at different moisture contents, Schofield was able to obtain curves like the typical one shown in figure 1. The hysteresis loop is strikingly shown.



An important practical consequence of the hysteresis is that the water in the soil tends to resist changes, whether these are in the direction of increasing or decreasing moisture content. Instead of moving through the pores from regions of high moisture content to low, it will adapt itself to the suction gradient mainly by an alteration in the configurations and curvatures of the water films. To use an expressive Americanism, the water "stays put" if it can. The bearing of this on the question of water supply to plant roots is obvious. The capillary theory taught that the drying due to water-imbibition by the roots was met by movement of water from the moisture regions, i.e. the water was brought to the plant roots. The correct view, however, is just the opposite: the plant roots have to ramify extensively through the soil in search of moisture. We can now see in their true light the real effects of

hoeing and rolling. The action of rolling is primarily the purely mechanical one of compressing loose but moist soil more closely around the roots of the young plant, so that they can more easily obtain the moisture. For any water movement of the type postulated in the capillary theory to take place, the soil would have to be so moist that no farmer would think of ordering the operation: the results on soil tilth would almost certainly be disastrous.

As for hoeing, there can be no general upward movement of water except in those cases of low-lying land where a water-table is very near the surface, and even then the rate of upward movement is exceedingly slow. In this case, as in the much commoner one where the water-table is well below the surface, the tendency of the water to resist changing conditions means, in effect, that it evaporates in situ; the dried-out surface layer progressively deepens. Most soils are, in fact, "self-mulching", and the use of a hoe to produce a soil mulch is, from the viewpoint of direct water conservation, a work of supererogation, except for those soils that tend to produce a hard crust or cap when drying. In these cases hoeing will break the crust in its incipient stages and so save the tender roots from damage. Of course, by destroying seedling weeds, hoeing prevents their competition for the available moisture and thus, indirectly, the operation conserves water.

The correct idea of soil moisture relationships, outlined above, enables us to form a clear picture of what happens to the rain when it has reached the soil. The soil is, normally, in the condition known as crumbs or compound particles. The crumb is an aggregate of soil particles, especially of the finest ones—the so-called clay fraction—which display this property of aggregation to a marked degree. The crumb itself is permeated by minute pores, much smaller than the pore spaces between the crumbs. If the soil is fairly dry and rain then falls, it enters the minute pores of the crumbs in the top layer. The excess rain passes downwards through the larger and cell-like pores between the crumbs and, in turn, each layer of crumbs levies toll on it. Depending on its amount and on the initial moisture content of the soil, the fate of the rain will fall between two extremes: it may be held wholly in the upper layers of soil—a frequent occurrence for summer showers—or it may displace water already in the soil, which percolates downwards until it reaches the water-table—a condition which is common in winter, when the pore spaces are practically saturated. Each soil crumb can be regarded as a minute water reservoir which, with any water left behind as a film in the bigger pores between the crumbs, is actively sought out by the exploratory root hairs on the plant's ramifying root system, which traverses its zone of growth so completely that the root hairs are never far away from a supply of moisture. This root system ranges much deeper than is generally thought, because few subsoils are so tight as to offer a complete barrier to the passage of roots and moisture. Studies of root behaviour made in America, and to a lesser extent elsewhere, show that the roots of common agricultural crops reach a depth of several feet: wheat, oats and sugar-beet, 5 to 6 ft.; barley, 3 to 4 ft.; and potatoes, 3 ft. The water-holding capacity of the zone of soil traversed by plant roots is considerable. A 5 ft. depth of soil holds at least $7\frac{1}{2}$ in. of rain which, with summer rain, is ample for the transpiration needs of a good crop.

Modern science has shown, therefore, that cultivation operations have only a minor influence on the moisture regime of the soil and, in consequence, much of the traditional belief on this subject must be abandoned or recast. When these traditions are examined closely it is seen that although they embrace the three factors, cultivation, moisture, and plant growth, many are short-circuited into a direct relation between cultivation and plant growth. The gardeners' exhortation to "keep the hoe moving among the crops" is a familiar example, and it is no exaggeration to say that most farmers believe that their crops will suffer by just the amount that their cultivations fall short of perfection. The belief was instinctive. The art of cultivation was well established long before agricultural science developed, and the practical man naturally felt that the operations were so obviously fundamental as to lie right outside any need for experiment. In settled countries innumerable field experiments have been made on artificial fertilizers and the number of such tests is still increasing, but experiments on cultivation were hardly ever made; yet the costs of cultivation are the heaviest single item in the arable farmer's budget and far exceed those for artificial manuring. In countries where agricultural development came later, experiments on cultivation were made, notably an extensive series in the Great Plains region of America, but

the results were ignored in this country for the apparently adequate reason that as they were done in an area of low rainfall, the conclusions could not possibly apply to our own conditions.

Such was the position some dozen years ago, when cultivation experiments were begun at Rothamsted. Slowly but surely—all the more surely because it was against their preconceived ideas—the investigators were driven to the conclusion that crop yields were remarkably insensitive to variations in cultivation. All the experiments were full-scale trials: none can be dismissed on the grounds that it would not apply to practical field conditions. A variety of cultivation procedures was tested on different crops and in different seasons, and the work is still going on. The main results are briefly summarized in the next paragraph.

Subsoiling is a standby of many heavy-land farmers, but on the Rothamsted soil, which has a heavy clay subsoil, the operation produced no effect on sugar-beet. The normal preparation for root crops includes both autumn and spring ploughing, and if bad weather prevents the autumn ploughing some apprehension is felt as to the quality of the spring seed-bed; tests made with potatoes and sugar-beet as the crop showed that the double ploughing gave only an insignificant increase of yield over a single ploughing, and not nearly enough to pay for the cost of the extra work. Deep ploughing every year was no more effective than shallow ploughing, but there was slight evidence that an occasional deep ploughing gave a little increase in the yield of root crops. The nature of the seed-bed itself was also studied and it was found that it had little influence on the final yield. Many experiments have been done on the inter-row cultivation of root crops, in which the minimum hoeings necessary to keep down the worst of the weeds have been compared with a greater number of hoeings. For a number of years the result of the extra hoeings was either no increase in the crop or, more often, a significant reduction in yield, a result due in all probability to the inevitable damage done to shallow-feeding roots. In some of the later experiments on inter-row tillage an increased yield was sometimes obtained. The design of the experiments enabled this positive effect to be traced to one hoeing done in the early stages of plant growth, and the effect has been confirmed in experiments on another type of soil. It suggests that farm and garden crops are specially sensitive to weed competition in the early stages of their growth and that one hoeing then is worth many afterwards.

The net result of all this work is to show that, provided the crop has a reasonably fair seed-bed, that it is given a hoeing in its early stages, and that the worst of the later weeds are kept down, then any cultivation of the soil—whether before sowing or during growth—in excess of this minimum is of little direct value to the plant. The results are in harmony with those reached by the investigators on the Great Plains area, and they are in harmony with modern knowledge of soil physics. They are in conflict with a deeply ingrained tradition, which had at least three apparently sound reasons behind it, as well as the capillary theory. The first of these reasons was that until the Industrial Revolution provided the farmer with good implements he fought a losing battle against weeds: cultivation at every available opportunity was his only hope. The second reason was that cultivation in the early stages of plant growth sometimes produces striking results, and it was assumed that the yield would benefit correspondingly; the Rothamsted experiments have occasionally shown similar effects which have, however, disappeared by harvest time, so that the ultimate criterion—yield—has not been affected. The third reason was that keen and successful farmers were, almost invariably, enthuiastic exponents of the art of cultivation. This was perhaps the most cogent argument of all to the average farmer: surely these leaders' farms and bank balances proved that their views were correct. But the real reason for their success lay not in the artistry of their cultivations, but in another quality, for which a traditional reason also exists: "the master's footsteps are the best manure for his land".

If the present article had been written twenty-five years ago, when the vast majority of cultivation implements was horse-drawn, the results of the cultivation studies now discussed would have had little more than academic interest. A horse costs nearly the same to keep whether he is working or idle, so the real cost of cultivations was negligible. But now, few farms are without a tractor, and the bulk of all cultivations is done with power-drawn implements. A tractor, properly looked after, does not cost anything when idle, and the more it works the higher the fuel and oil bill. There is, therefore, a powerful economic reason to reinforce the scientific arguments for a complete and critical examination, on all types of soil, of our cultivation methods.

A COMMENTARY ON "PHYSICAL RESEARCH ON PROBLEMS OF SOIL CULTIVATION"

By G. H. Gethin-Jones, Soil Chemist, Department of Agriculture, Kenya

Dr. Keen's article gives a comprehensive account of our knowledge of certain aspects of the science of soil physics and its application to cultivation from the period of true and false traditional methods of early times up to the present day, when increasing numbers of specialized research workers are being engaged on all aspects of this relatively new science. Though much laboratory and field work on what may be termed the chemistry side of soil science was undertaken during the last century, the study of soil physics and the application of the knowledge gained to varying soil and climatic conditions was, unfortunately, largely neglected until about the beginning of this century.

Early investigational work on the proper principles of soil cultivation, which had hitherto been mainly traditional in character, was naturally devoted to a separation of truth from falsehood and scientific reasons could generally be given to account for sound methods of soil husbandry which had gradually developed. However, there was one outstanding exception, namely the true relation which was believed to exist between the long-established custom of frequent surface cultivations and the supposed resultant conservation of soil moisture and hence better crop performance. Gradually, soil workers became uneasy about the inadequacy of the simple "capillary" hypothesis. It is the relegation of this deeply ingrained tradition to the rank of a falsehood that is the main theme of Dr. Keen's present article.

The early hypothesis was that cultivation severed the continuity of the bundles of thread-like, water-conveying capillary tubes and thus reduced evaporation off the soil surface. It was believed that these capillary tubes could draw up moisture from very great depths. It was known that narrower tubes, such as might exist in heavy soils, could raise water to greater heights than the broader capillary tubes of sandy soils and this seemed to explain why heavy soils were better able to withstand drought. Rolling was also supposed to compress the surface soil so that broken water-conveying tubes were re-formed. Though laboratory experiments showed that the rise of water from a water-table varied between about two and four feet only, according to the texture of the soil, that the approach to the maximum was exceedingly slow, and that appreciable movements such as would be necessary to meet root requirements would only occur in very moist soils, it was thought that somehow or other things would work better in undisturbed soils in the field.

Haines, Schofield and Keen, working at Rothamsted, proved mathematically and confirmed by actual tests that the capillary hypothesis was entirely unsound. With other research workers, they have worked out the geometry of soil pore-space and the physical properties of the contained curved moisture films. They showed that pore-space could not be regarded as twisting, thread-like tubes, but as a spongy mass of cells communicating with each other through relatively narrow necks. They proved that local changes in the soil-moisture status could not be in a smooth continuous manner, but had to take place relatively abruptly by the sudden filling and emptying of individual cells. Dr. Keen's article gives a clear and convincing account of the cause and effect of what happens during the wetting and drying of soils; how regions of high and low moisture-contents can exist in equilibrium, and how water, throughout the soil profile, tends to resist change by alteration in the curvature of water films in the cells.

A more simple expression of these phenomena is that soil-water movement below that of "field-moisture capacity" is very slow and that a transpiring plant must depend largely on an intimate ramification of its root system throughout the soil to meet its water requirements. Under the capillary hypothesis, the water was supposed to come to the plant, but under the new theory the plant has to search for its water.

The visibly rapid draining of irrigation waters or heavy falls of rain takes place mainly through the larger pores of light soils and through the cracks in heavy soils, but this rapid gravitational displacement does not proceed beyond the limit of the field-moisture capacity; beyond this stage, moisture movements are limited to the slow processes expounded in Dr. Keen's challenging article.

The validity of the new theory has been demonstrated by numerous field measurements of the actual upward and downward movements of water in the soil profile. It has been

confirmed that these are largely independent of whether the surface soil is compact or whether it is in the form of a fine tilth. Surface cultivation can only conserve soil water by preventing the loss of moisture through weed growth and this only happens when such losses, coupled with that from the partly shaded soil, are greater than the loss by direct evaporation from a bare soil during similar climatic conditions. The most interesting results of these Rothamsted cultivation trials are that extra cultivation beyond the minimum necessary to establish the crop and to suppress weeds has no appreciable effect on crop performance.

As readers are likely to cast their minds back to earlier teachings and subsequent experiences which may make the new theory difficult to accept, it is important to bear in mind its implied limitations. It does not apply to moist soils containing capillary water such as often obtain in East Africa during the rainy seasons; it does not apply to soils of impeded drainage or those with ground-water within a few feet of the surface; and finally, it does not apply to the movement of soil moisture in the form of evaporating or condensing water. The theory is only applicable to water movements below that of "field-moisture capacity" in deep, freely drained soils.

Certain implications of the new theory have a special bearing to sub-tropical conditions with long-continued seasonal droughts. Some soil-moisture determinations carried out with the Kikuyu red loam at the Scott Agricultural Laboratories in 1933 showed that, following the rainy season, the upper nine inches of a bare soil with a good, natural mulch, did, in fact, lose more moisture than a similar soil carrying a cover crop of *Glycine javanica*. This vigorously growing cover crop with much surface feeding roots must have transpired much water, but the concomitant reduction in direct evaporation from off the surface soil and from within the subjacent layers more than made good the transpiration losses. This is probably explained by the habit of the cover crop of providing a dense shade and thick litter, resulting in a much cooler and sheltered surface soil. An outstanding result of these field trials was the remarkable efficiency of a thick vegetable mulch in conserving both top-soil and sub-soil moisture.

The high vapour-pressure exerted by the soil moisture in a warm unshaded soil, coupled with the continual diurnal displacement of the soil atmosphere, would hasten the downward desiccation of the soil during dry weather. Where deep shrinkage fissures develop, the progressive drying of the surface and subjacent layers is greatly accelerated. A sunny western slope and a prevailing warm drying wind also favour a more rapid drying of the soil. Shelter, shade, a surface cover and all factors making for a cooler soil favour moisture conservation. It is probable that a shallow soil mulch, natural or induced, as compared with a compacted surface soil also tends to reduce the loss of soil moisture to the atmosphere, but can only do so to a limited extent.

The lessons to be learnt by East African cultivators in regions of limited rainfall are: the early seeding of seasonal crops; the limiting of cultivation to that required for the preparation of a seed-bed and the control of weeds; and the adoption of cultivation practices that limit the exposure and heating of the soil. Dr. Keen's article further emphasizes the value of such soil conservation measures that all the rainfall percolates into a stable surface soil.

Although we must largely concentrate on matters which are of immediate urgency, the relatively slow march of science should not be halted. It is quite right to urge, as a war policy, that we should reduce the use of luxuries, but it does not seem right to classify scientific work under this head. The research work of entomologists, in any country, involves only a small number of workers, and the publication facilities which they need are, as compared with other types of publication, exceedingly small. There should, indeed, be a stepping-up of research, with increased rather than diminished facilities. This not only for economic reasons but as promoting a sane outlook on life.

Prof. T. D. A. Cockerell, University of Colorado
(Extract from *Science*, Vol. 96, p. 338, 1942)

E. S. Craighill Handy in the foreword to his book "The Hawaiian Planter" (*Bernice P. Bishop Museum Bull.* 161) records his conviction, "which has steadily grown through nearly twenty years of ethnological study, that humanity is neglecting one of its richest endowments in failing to record, utilize, and conserve systematically the knowledge of indigenous agriculturists who have dwelt with their native soil and plants through millennia".

In any controversy the instant we feel anger we have already ceased striving for truth and have begun striving for ourselves.

Thomas Carlyle.

REVIEWS

THE COMPOSITION OF KIKUYU GRASS UNDER INTENSIVE GRAZING AND FERTILIZING: Department of Agriculture and Forestry, Bulletin No. 203 (Soil and Veld Conservation Series No. 3), Union of South Africa, 1941.

This chemical study by A. J. Taylor of the intensive management of Kikuyu grass pasture at the College of Agriculture, Cedara, is of interest to farmers in the favoured highland areas of East Africa, particularly those of Kenya. It has been repeatedly asserted that in our natural Kikuyu grass region we possess a pasture type unsurpassed in any other part of the world, but it must be admitted that little progress has yet been made in practice towards the correct management of this highly productive pasture. Research in Kenya has indicated the absolute necessity for intensive management of Kikuyu grass as against the prevalent practice of ranching extensive estates (see "The Reaction of Kikuyu Grass Herbage to Management", *Emp. Journ. of Exptl. Agric.*, Vol. VIII, No. 30, April, 1940), but little investigation on the chemical side of this work has been attempted. In the bulletin, Mr. Taylor summarizes the experience of intensive rotational grazing of Kikuyu grass paddocks at Cedara over a period of eleven years, in regard to manurial treatment, yield of dry matter and nutrients and yield of milk obtained. This last amounts to approximately 1,000 gallons per acre in the growing season of seven months. The paper concludes with an estimate of returns, and although this is admitted to be incomplete, the margin remaining after deducting the cost of artificial manures and supplementary feeding (with milk at 4d. per gallon) provides convincing evidence of the economic soundness of the method of management employed.

The remarks in the bulletin on soil requirements and the failure of earlier light grazing management to maintain the Kikuyu grass sward are in keeping with the findings of ecological study of the pasture type in Kenya, but an outstanding feature of the account is the high figures given for crude protein content of the pasture. These range over a period of years from 17 to 28.2 per cent of the dry matter and are considerably higher than figures obtained in East Africa. How far the results can be attributed to the indirect effect of the liberal dressings of nitrogenous manure applied throughout the experiment is not clear, as no control subjected merely to the grazing treatment was provided. It is self-evident, however, that when the development of the natural Kikuyu grass areas of Kenya advances, as it should, to a system of intensively managed small farms, the return of the minerals removed in the milk will eventually become a necessity. The question of the nitrogen supply and the yield of protein, however, requires further investigation. In the highland region of East Africa the natural clover, *Trifolium Johnstonii*, is associated with Kikuyu grass, and as it was pointed out in the paper on "The Reaction of Kikuyu Grass Herbage to Management" already quoted, there appears to exist a balance between this clover and the grass, on which the maintenance of soil fertility largely depends. The control of the proportions of clover in the sward and the vigour of the grass are dependent upon judicious intensive grazing. It is, therefore, reasonable to suppose that by far the most expensive item of manurial treatment, heavy dressings of sulphate of ammonia, recorded in the Cedara experiment, might at least be considerably cut down in East Africa, particularly as no mention of leguminous constituents of the herbage is made by Mr. Taylor. This is the more important as the cost of the fertilizer is much higher in East Africa.

In conclusion, one further point should be stressed in regard to this work. It should be made clear that the practical use of Kikuyu grass is limited to climatic conditions which are exceptionally favourable for both East and South Africa. The Cedara experiment was carried out under an average annual rainfall of approximately 35 inches with a growing season of seven months' duration. In East Africa, where higher temperatures obtain, the grass occurs naturally, and can be utilized successfully, only within the highland area, roughly bounded at the lower limit by the 6,500 feet contour, and under an average annual rainfall of 40 inches. The region is, however, of considerable extent, and in Kenya the potential Kikuyu grass country has been estimated to be from 7,000 to 8,000 square miles.

D.C.E.

BRITISH AGRICULTURAL RESEARCH, ROTHAMSTED: By Sir E. John Russell, F.R.S. Longmans Green & Co., 1942, pp. 32. Price Sh. 1.

This is a very readable account of the history, development and achievements of this famous experimental station which has probably done more to stimulate and influence the

growth of agricultural research than any other similar organization. The account of the provision now made for research at Rothamsted, which is only one of many such institutes in Britain, is a sad reminder of the inadequate provision made for agricultural and related research in East Africa. Referring to the problems of the future the author concludes: "The great national problem after the war will be to combine the necessary degree of planning with the individual freedom for which we are now struggling and which in the past has resulted in so many distinguished achievements. Science flourishes only in an atmosphere of freedom, and while it can render much better help to a planned than to an unorganized agriculture it cannot tolerate being dragooned. Further, it cannot rectify a bad economic policy. Our hope is to find the happy mean between too much planning and too little."

A.G.H.

We have received an advance notice of the following:—

The Diagnosis of Mineral Deficiencies in Plants—A Colour Atlas and Guide: By Dr. T. Wallace, of the University of Bristol, Agricultural and Horticultural Research Station, Long Ashton, Bristol. Published by H.M. Stationery Office, Price Sh. 10.

We hope to arrange for a review in due course, when the book has been received in East Africa. Meanwhile it may be said that the main bulk of the book consists of one hundred and fourteen colour photographs, which show the characteristic changes in the plants' appearance due to the different deficiencies. In addition there is a descriptive text and key. These features should commend the book to a wide circle of those interested in agriculture and horticulture.—Editor.

THE PUBLICATION OF SCIENTIFIC WORK

We need the development of a different point of view in regard to publication, a point of view that will lead eventually to the elimination of the trival and useless and that will encourage and support the publication of material that is important and significant. This should not be by any placing of tyrannical power in the hands of editors, but by a building up of standards such that a contributor to a journal would be ashamed to submit such childish material as much which encumbers the past volumes of our entomological journals. And we need someone to fathom for us the secret of how the Germans were able to publish such pretentious and apparently economically impossible—and at the same time such colossally bad—works as those which at one time issued in such numbers from that nation. If we could fathom that, perhaps we could find a way to publish really good comprehensive works in the United States.

* * * *

There is no man in the world who can give you a definite identification of any but perhaps a dozen common species of mealybugs. To go any further than that requires that someone shall sit down to an investigation of the systematics of the family Pseudococcidæ for the whole world, not just of some small area, or not just of a few species. It will require at least three years of steady, laborious, eyestraining work before the business will be in any shape at all, and if he has it anywhere near done in that time he will have to work rapidly and efficiently and have adequate help in the form of assistants to make slides for him.

Then, with this work done, with the resulting paper, amounting to two fat volumes, on the mealybugs of the world ready for publication so that the work will be available for general use, all the systematist will have to do will be to hunt around for some way of publishing it, and in the end either dig up out of his own pocket or pare the paper down until it is emasculated or file it away to become obsolete. A government that will throw around billions of dollars on projects that have political significance will gag at spending a couple of thousand dollars to publish such a work as this. No private publisher will touch it, for there is no hope of profit. The number of foundations that will grant money in sufficient amounts for the publishing of such a work is exceedingly limited.

And yet it is work of this sort that we need above all. That is the way it should be done. That is the scale on which systematic entomology that is going to produce something worth while should be conceived and executed.

G. F. Ferris in *Journal of Economic Entomology,* Vol. 35, Oct. 1942, pp. 737 and 738.

NOTES ON ANIMAL DISEASES

Compiled by the Veterinary Department, Kabete, Kenya

XX—STERILITY IN CATTLE

Sterility is a vast subject, and it is only possible to deal with it briefly in an article in this series. Sterility and mastitis are two of the major problems with which the British dairy-farmer is faced, and in Kenya, sterility has been, and still is, the cause of great wastage in dairy herds. Like many other causes of loss, sterility is to a great extent bound up with the general question of creating a more highly-productive type of animal. Unless great care is exercised, it is only too easy to increase the productivity of a strain of animal at the expense of constitution and fecundity. In Kenya we have unfortunately another factor, a contagious disease which appears to be limited to Central Africa, and which produces pathological changes leading to complete sterility in grade and pure-bred bulls and in a percentage of female stock.

Cases of sterility may be divided into two main groups, physiological and pathological. The former group contains those cases in which the organs producing germ-cells fail to function normally, those in which malformation is such as to preclude any possibility of conception taking place, and those in which some physiological factor operates to prevent the foetus being carried to term. The latter group includes conditions in which infection is responsible for preventing conception or for destroying the foetus *in utero*.

Taking the first group, the commonest form of physiological sterility seen in Kenya is that of the insufficiency type. In the female the main symptom of this type is failure to come on heat. The condition is commoner in young heifers than in cows, and at Kabete is more in evidence during dry periods. It is possible that a shortage of vitamins in dry pasture is to some extent responsible for some of the cases in which sexual activity, temporarily, seems to be suspended. In a less severe form, there may be lack of tone in the female genital tract, so that, even although ovulation and oestrus occur, the ovum is weak or the mucosa of the uterus is not sufficiently normal for conception to occur.

Similarly in the bull we see occasional cases of young, apparently healthy, bulls which take no interest in cows on heat.

When this form of sterility occurs, and in particular when it persists for several months, including a rainy period, fattening and slaughter are recommended. Those who wish can try the treatment of what they consider valuable animals with oestrogenic preparations, such as dimenformon. One must, however, point out that any progeny obtained may be even worse breeders than their parents, so the herd is probably much better off without them.

Although strictly speaking a type of pathological sterility, it is convenient to mention here failure to come on heat when a permanent lesion is produced in the pituitary gland as an after-effect of foot-and-mouth disease. This type of sterility occurs in a percentage of cows after any severe outbreak, the animals often showing in addition a rough "woolly" coat and "shortness of breath". In these cases the lesion responsible for failure to ovulate is the direct result of a disease process and there is no reason to expect that it will be transmitted to the calf. If cost is not prohibitive the use of oestrogenic preparations is, therefore, indicated.

To turn now to another form of physiological sterility, we have the cases in which the cow comes on heat regularly or even more frequently than normal, signs of heat are very marked, and yet conception does not occur. These symptoms, of course, are common to many forms of sterility; but we are now considering only those in which there are no pathological changes caused by disease in the genital tract. Such cases are rare in Kenya; but it would appear that nymphomaniac cows with cystic ovaries, in which breaking of the cysts results in conception, are encountered occasionally. Treatment is best left to a veterinary surgeon and, in this country, diagnosis can be confirmed only by results.

Other forms of physiological sterility due to malformations of the genital tract need no further mention. Obviously as "freaks" they are undesirable as breeding stock.

The commonest form of pathological sterility, in fact the commonest cause of all sterility in cattle in Kenya, is a specific disease, contagious cervico-vaginitis and epididymitis of cattle, or what at Kabete is usually termed "epivag" for short. This is a specific disease transmitted from bull to cow and vice versa during service. Experimentally the disease has been reproduced in the bull by the intra-urethral injection of discharge from an infected cow and of an extract of epididymis of an infected bull. The actual agent responsible for

the condition has not yet been identified; but experiments suggest that it is a virus.

In the bull it would appear that there is a temporary lesion on the penis or sheath, but the serious changes are those which begin to occur in the small tubules of the epididymis about six weeks afer infection. These changes lead to blockage of the tubules and the spermatic fluid from the testicle is unable to pass through to the *vas* and urethra. The bull is thus rendered completely sterile and the changes are such that treatment is quite impossible.

Clinically, in the bull, the disease is rarely detected until at least three months after infection, when the epididymis, usually at the lower end of the testicle, becomes obviously enlarged and hardened. In advanced cases the large, swollen end can be seen when standing behind the bull; but it is, of course, necessary to examine by feeling to detect the changes during the early stages.

In the cow, the earlier symptoms consist of reddening of the mucous membrane at the anterior end of the vagina and of the presence of an odourless, sticky, opaque, yellowish discharge. The discharge dries on the tail at the lower level of the vulva and on the buttocks, where it is desposited by the tail. At the latter site it forms scales resembling dried shellac. In some animals infection of the vagina and os is transient, but in others it is very persistent. Whilst present the animal is often, but not always, sterile, and were infection to be confined to the vagina and os, the disease would not be so serious in so far as female stock are concerned. Unfortunately, however, in about 25 per cent of cases, infection spreads up the genital tract until it reaches the Fallopian tubes, the narrow ducts which lead the ovum from the ovary to the uterus. Here changes are produced similar to those that occur in the epididymis of the male and blockage of the tubes is produced. In the majority of cases blockage is at several points and, since the mucous membrane continues to secrete, a chain of cysts is produced. It is obvious that, when both tubes are occluded at several points, the animal is rendered permanently sterile and, as in the bull, no treatment can hope to be effective.

In the control of this disease, attention must be concentrated on prevention. It is in this respect that artificial insemination has proved so useful in Kenya, for by using artificial insemination the bull, frequently by far the most valuable animal in the herd, is protected. When vasectomized native bulls are used to pick out the animals on heat there is, of course, every opportunity of infection being spread amongst the female stock, and when possible "teaser" bulls should not be used.

Cows and heifers which have active lesions in the vagina and cervix should be treated. A proprietary brand of pessary, now unfortunately very difficult to obtain, was the simplest method of treatment. Good results have also been obtained with an iodine solution consisting of iodine (1 part), potassium iodide (2 parts), water (90 parts). In using this solution, the vagina is first cleaned by irrigation with water sterilized by boiling and then about one ounce of the solution is injected to the anterior end. Treatment should be repeated once a week until the vagina is clean. In deciding whether an animal is clean, care should be taken that reddening due to the use of a speculum is not mistaken for reddening due to disease. The normal white-of-egg discharge which is sometimes present during oestrus should also be disregarded. It will be found that some cases respond well to treatment, but others are very obstinate and these should be sold for meat.

"Epivag" appears to be an East African disease, and it is probable that our zebu cattle are less susceptible than grade and pure-bred stock. Cases of local vaginal infection occur in native stock, but it is rare for Fallopian tube lesions to be seen in native cows and heifers. We have not seen genuine epididymitis lesions in pure native bulls.

Of other diseases which have been reported to cause sterility, the so-called "contagious granular vaginitis" should be mentioned. This condition is characterized by the presence of small red, granular lesions in the vagina near the vulva. This condition has been seen in young heifer calves. At the end of a dry spell it is often widespread in dairy herds, and it is unlikely that, in itself, it is responsible for breeding troubles. It is possible, however, that it indicates some deficiency which may also cause subfunction of the female genital organs. Modern experience certainly is against the theory that it is contagious.

Contagious abortion has already been described in these notes. In this disease, retention of the afterbirth is common and this leads, on occasion, to septic metritis (infection of the uterus). A uterus full of pus, or of which the lining membrane has been severely damaged, is, of course, an unsuitable site for the development of the foetus. Metritis can also follow infection with the protozoan parasite, *Trichomonas foetus;* but although a careful watch has been kept, this parasite has, up to the present, not been encountered in Kenya.

CONTRIBUTION TO STUDY OF PROBLEM OF BUSH FIRES FOR HAUT KATANGA*

By P. Quarré, Agronomist-Botanist, Member of the "Société Royale de Botanique de Belgique", Corresponding Member of the "Jardin Botanique de Bruxelles"

General Observations

It is a generally recognized fact that the soils of the Haut-Katanga are poor in humus. This is due largely to the annual bush fires. The fire destroys the organic matter—micro-organisms which are indispensable to plant life—and it makes the soil sterile. The addition of ashes does not compensate for the loss in humus-bearing materials.

It is certain that the annual bush fires modify considerably the biology of plants by favouring vegetative reproduction; many species of the flora of the Katanga are capable of reproduction by means of underground shoots, stolons, rhizomes. They were made to give up reproduction by seed in favour of asexual reproduction. But how many natural plants, unable to adapt themselves, have thus disappeared forever from the Katanga?

Bush Fires and Game

After the month of June, the dried-up grasses are no more grazed by game. If the game still feeds on the more persistent herbs which retain green leaves into that season, these are not sufficient, and areas already burnt off, where the young grass shoots rapidly, are sought out. If the large savannas were to be preserved from fire it is very probable that the game would desert such regions. This fact is known by the native hunters, who burn off certain parts of the savanna in order to keep or to attract the game in the dry season. It follows that for purposes of conserving game in certain regions, annual grass fires are a necessity.

Grass Fires and Large-scale Cattle-farming

The large cattle-farming concerns in the Katanga are divided into numerous sections with an area of 15–20,000 hectares, each with a total of 3,000 to 5,000 head of cattle. Here too a scarcity of grazing is felt during the 4–5 months of the dry season. The valleys remain more or less green during the whole year only near the rivers, but these areas are too restricted to supply enough grazing for the number of cattle; there is, in addition, the danger of fly in the gallery forests near the valleys.

In order to remedy this scarcity of grazing, the cattle farmers burn methodically and according to a concerted plan the area of grassland that they need for pasture. It is known that new grass will develop about five weeks after burning.

We have observed nevertheless that when fire passes through a savanna which has been protected from burning during several years the damage will be fairly considerable; the fierce fires fed by large masses of very dry vegetable matter penetrate into the top soil, killing the roots and thus baring the soil.

Bush Fires on Cultivated and on Improved Pastures

In cultivated and improved pastures fire is a real disaster. Many of the grasses introduced in these pastures are annuals, and they reproduce by disseminating their seeds. These seeds being ripe in the dry season, the fire interrupts the continuity of the annual species; it also weakens the root system of the perennial grasses.

As regards the soil, it will become sterilized and impoverished with—among other results—the disappearance of the micro-organisms which are indispensable to plant life.

But the question of burning should not arise for cultivated and for improved pastures; with methodical, continuous and well-planned grazing they should be kept continually short in the same manner as the pastures in Europe.

Bush Fires in Tree-, Bush- or Grass-Savannas Used for Pastures

These savannas, which are used as non-improved pastures, are still popular with the farmers in the vicinity of Elisabethville. Here bush fires should be avoided. To prevent grasses from going to seed and subsequently drying up a sufficient number of cattle on a given area would keep the grasses down by continuous grazing.

This simple method would save the farmer from:—

(1) Degradation of soil.
(2) Loss of humus.
(3) Erosion.

* Translation by Peter R. O. Bally, Botanist, Coryndon Memorial Museum, Nairobi.

(4) It would allow for a considerable reduction in the size of his pastures which would, incidentally, simplify the management of the herds. It would also mean a saving in manure, which would be distributed over a smaller area.

Unfortunately this method can be adopted only with certain grasses belonging to the *Panicum* and *Poa* group, such as species of *Digitaria, Beckeropsis, Paspalum, Eleusine* and *Setaria,* and it would give no practical results with grasses of the *Andropogon* group.

Bush Fires and Forestry

Bush fires cause the more damage to woody vegetation the higher the herbaceous vegetation associated with it; the less dense the forest the more vigorous the herbaceous plants.

Where a cut-over or a naturally open forest is not protected from fire, natural and spontaneous regeneration is practically impossible.

Not only the seedlings and the young shoots are roasted by the fire but the ripe seeds which fall on the soil are burnt before they can germinate.

The more the trees have been weakened by the passage of fire, the more easily they are subject to attack by termites, constantly on the alert for the slightest lesions in the bark.

Burnt forests have nothing left with which to develop humus, while forests protected from fire form their humus with the aid of fallen leaves and of the herbaceous plants which are laid down on the soil each year and are decomposed by the rains.

As it is practically impossible to avoid bush fires, the following procedure might be adopted:—

Burn the herbaceous plants in forests during the first half of the dry season; during that period the herbs are only partly dry and they burn less fiercely; the trees are then in their state of rest and the flames cause relatively small damage.

Fire passing through a plot which has been partially burnt at the beginning of the dry season will cause relatively little damage in October, there being little dry matter left to feed it.

On the other hand, fire passing through a forest at the end of the dry season is extremely destructive because, the herbaceous plants being very dry, the fire catches and even roasts the young shoots and buds and this causes a call on the tree for increased supply of sap which exhausts the tree unnecessarily and very considerably.

There are certain species of trees which enter their vegetative period very rapidly 4–5 weeks before the rain break; these recover only with difficulty and after a few years of regular late fires they disappear entirely.

The method of early burning is being closely studied in the forests under the administration of the Comité Special du Katanga.

Observations made in the Clearings of the B.C.K. along the Railway Lines

Our observations agree with those made by the foresters of the C.S.K. concerning the effect of bush fires and their influence on the regeneration of forests. The sum of these observations is that bush fires started towards the end of the dry season:—

(1) Destroy 95 per cent of the small plants:

(2) Cripple 90 per cent of the plants which have resisted the fire:

(3) Damage 50 per cent of the plants with scars, burns, etc.

(4) 30 per cent of the seedlings and 60 per cent of the new suckers show defects which must be attributed entirely to burning.

On the other hand, on a strip of 100 metres on either side of the railway line, the forest regenerates itself naturally in a very satisfactory manner with thick undergrowth, natural seedlings, suckers and coppice shoots. The stems of the trees are straight, with smooth and healthy bark, because the herbs are hardly dry when they are set on fire by the flying sparks of passing locomotives; at that time of the year the fire is poorly fed, the flames are insignificant and the damage is practically nil.

These fortuitous burnings constitute the best example of the results which can be obtained by early burning.

Experience and Observations made in a Plot Preserved from Annual Bush Fires

A plot of one hectare has been preserved for ten years from annual burning. We have been able to make comparisons with a plot of the same size subjected to annual fires. In the protected plot—

(1) The trees are taller.

(2) The leaf canopy is denser and the herbaceous plants attain only half the height.

(3) Trunks, shoots, etc., are straight, whereas in the burnt plot they are crooked and forked.

(4) The bark is smooth and healthy, whereas in the burnt plot it is scarred and frequently attacked by termites.

(5) The thickness of the humus is 8–10 mm., whereas in the plot subjected to annual burnings there is no humus.

Conclusions

In this note we have summarized objectively some observations concerning the very complex question of the annual bush fires in the savannas of the Haut Katanga from the various angles from which this vast problem must be approached. At present the study of the biological and geo-botanical influences has hardly been developed; in fact, so little work has been done on the subject that we can state that it is only in its initial stages of scientific research.

When this problem is solved and an adequate method can be practically applied in each individual case, science will have made an important contribution to the economic development of the country.

(*Received for publication on* 18*th February,* 1943)

QUININE IN LEGEND AND HISTORY

The discovery of the value of quinine in medicine has been told for a period of nearly three hundred years in many books and journals of repute. The Countess of Chinchon has accordingly received the gratitude of millions of people, while her physician who did much to make the discovery known in Europe—so the story goes—has had his due share. A correspondent, to whom we express our obligation, has referred us to the *British Medical Journal* of 28th February, 1942, for the latest information, which conflicts with the account that has served mankind for nearly three centuries.

We gather from the *British Medical Journal* that the official diary of the Count of Chinchon is still in existence and has recently been carefully studied. The Count had two wives and it was the first, according to the legend, who was cured of a fever in Peru by means of quinine. The story does not really fit either wife, the first one died before the Count went to Peru; the second one did go to Peru, but never had fever; she was not cured of it by quinine or any other bark or drug; she did not make known in Europe the virtues of quinine on her return to Spain, for she died before she reached Spain. Nor did her physician spread the glad tidings in Europe, for he remained in Peru until his death and was apparently not acquainted with the curative powers of quinine. He and his colleagues made use of bleeding and prayer when they had to deal with a feverish attack. We are not attempting to pronounce our own judgment on these slightly conflicting versions; we are merely providing an abstract of what the *British Medical Journal* says about the study of one Haggis on the contents of the diary of the Count. The details given by the *British Medical Journal* are sufficient to throw a little doubt on the older version of the discovery without conclusively proving the truth of the new version. We give a brief summary of this so that our readers can draw their own conclusions. Here it is. During the early part of the seventeenth century medicinal substances were exported from South America to Europe, and one of these was Peruvian balsam obtained from the bark of *Myroxylon peruiferum*. This balsam was used in Rome and perhaps elsewhere as a febrifuge. The native name for this tree was quinua-quinua, otherwise quina-quina. When the supply of the genuine article became difficult the Peruvian exporters adulterated the genuine balsam with the bark of the cinchona tree. The name quina-quina sufficed for the mixture and was gradually applied to the substitute; hence arose a certain amount of confusion between the *Myroxylon* and the "Arbol de Calenturas", otherwise the fever tree or cinchona.

Chemistry and Industry.

CORRESPONDENCE

The Editor, East African Agricultural Journal, Amani

Sir,

The very interesting paper by Dr. Fairbairn, "The Agricultural Problems Posed by Sleeping Sickness Settlements", published in your July number, deals with many of the difficulties involved in making and maintaining permanent settlements, isolated in the great expanse of tsetse bush, but it omits one, that of permanent fuel supply.

In the example given a thousand families are moved into 25 square miles of bush country and clear half of it in eight years. The time taken to clear the balance is not stated, but assuming it is half as long again, the whole area is cleared in 20 years.

With access to plentiful firewood an African family uses about 50 cubic feet a month, and to obtain this or a portion of it after the first 20 years, the women will have to go daily into the fly-infested bush surrounding the settlement. Those living near the centre will walk 2½ miles out and 2½ miles back, and as the available wood near the edge is reduced, the distance and consequently the time lost to cultivation will increase.

There will presumably be some fuel available from bush growth in resting *shambas* and grazing grounds, but building poles, tool handles and other wood are required as well, so it can be assumed that the annual needs of this settlement are something like 600,000 cubic feet a year.

Inevitably dangerous journeys will be made into fly country, the volume of fuel and the number of poles used will be reduced, to the detriment of cooking and standards of housing, and probably cow dung will eventually be burnt instead of being used for manure. When this stage has been reached the only remedy is planting, and the only land available will be swamps and poor soil, which are expensive to afforest and do not give high yields. About 2,000 acres would be needed for the permanent supply of the settlement and the cost in paid labour on the equivalent time of communal labour would be anything up to £20,000 for establishment in a period of ten years.

In Uganda the cost to an industry of the 600,000 cubic feet of fuel used each year would be £1,200, and possibly in some parts of East Africa it would be more, so if the plantations were formed for industrial supply the return on the investment would probably be adequate. The African has always regarded firewood as one of the free gifts of nature, like air and water, and it is unlikely that the budget of a peasant farmer could stand the additional expense of Sh. 24 a year for fuel. If a charge were made for plantation fuel he would probably prefer to send his wife into the fly bush for firewood; so recovery of, or interest on, the money spent can be ruled out.

The supply could also be assured by individual planting of two acres per household, but it is improbable that many peasants could be persuaded to do this while there was still a tree standing within five miles. The African does not anticipate shortages and is loth to plant trees in time to be ready for use when existing supplies will be exhausted. This attitude is by no means peculiar to the African, and one of the ways in which his European mentors have failed him is that they have allowed peasant fuel supplies to reached a dangerously low level in many densely populated districts.

I do not know where the money is to come from to grow fuel in the denuded areas, but I do think we can and should prevent this stage being reached in areas to be developed in future. Mr. Napier Bax in his paper in the same number of the *Journal* indicates that in some types of fly-invested vegetation, isolated patches of trees could be left cleared in settlements without fly danger. If this is so, some form of reservation and management of "village forest" woodlots, suitable to the tribal organization concerned, can be evolved in many settlements in fly country and certainly in all new development in areas free from fly. Natural savanna of many types can be made permanently productive if protected from fire and grazing, given some inexpensive treatment and managed so that only the annual increment is cut each year.

The area required for the supply of a given quantity of fuel will be larger than that needed for the same output from plantations, but the method appears to be the cheapest that can be evolved for permanent supply of forest produce. It has the added advantage that a certain amount of timber for sawing can be grown with the fuel and poles, to be ready for the time when better housing and more furniture will be used.

A number of trial areas in various types of savanna of new dam-settlement sites are now being treated by the Lango Native Administration with the assistance of the Uganda Forest Department, and valuable experience is being gained.

The essential point about any such scheme is that the potential forest areas must be selected and preserved from the beginning, even though the produce from them will not be wanted for 20 years. The blocks should be scattered about the settlement for convenient access by all, and often they can be sited so as to combine some protective function with production.

In the inevitable preoccupation of medical and administrative authorities with more immediate problems of settlement, provision for future supplies of forest produce is obviously likely to be overlooked, but it is nevertheless essential for permanent prosperity.

Yours faithfully,

N. V. BRASNETT,

Conservator of Forests, Uganda Protectorate

Forest Department,
P.O. Box 31, Entebbe, Uganda.
18th August, 1943.

THE USE OF BONES AS A FERTILIZER

Dear Sir,

During the late drought there were large losses of cattle and sheep, and therefore there must be a good number of bones lying round the countryside. In view of the scarcity of fertilizers, and the price of the same, the following extract from Snyder's *Soils and Fertilizers* (1916) might well be of interest to farmers, I think.

Yours faithfully,

RICHARD N. SAVORY.

Kipkabus, 14th June, 1943.

"Raw bones contain, in addition to phosphate of lime, organic matter which makes them slow in decomposing and slow in their action as a fertilizer. Before being used as a fertilizer they should be fermented in a compost heap in the following way, a protected place being selected so that no losses from drainage will occur. A layer of well-compacted manure is covered with wood ashes, the bones are then added and well covered with ashes and manure. From three to six months should be allowed for the bones to ferment. The large coarse pieces may then be crushed and are ready for use. The presence of fatty material in a fertilizer retards its action because fat is so slow in decomposing. Bones from which the organic matter has been removed are more active as a fertilizer than raw bones. There is from 18 to 25 per cent of phosphoric acid and from 2 to 4 per cent of nitrogen in bones. The amount and value of citrate-soluble phosphoric acid are extremely variable."

Mr. Gethin-Jones, Soil Chemist, Department of Agriculture, comments as follows:—

There is no need to treat bone in a compost heap previous to grinding. The organic portion of bonemeal is very readily decomposed under local field conditions, as shown by the early appearance of a mass of feeding roots in pockets of soil enriched with bonemeal. It is probable that this rapid decomposition of bone proteins in intimate contact with the calcium phosphate is largely responsible for the very "early availability" of the phosphate portion of bonemeal. In fact, laboratory work on the comparative availability of bonemeal and bone-ash to wheat seedlings showed that when the organic matter was lost by burning and the natural open structure destroyed, the phosphate intake within eighteen days after seeding was greatly reduced. It was 17 per cent of the total contained phosphate when bonemeal was used, as against only 5 per cent when bone-ash of the same degree of fineness was used. The ashing of bones not only destroys the valuable nitrogenous organic matter but also renders the phosphate portion less readily available.

Waste bones should be ground into a bonemeal of a suitable degree of fineness and applied to the land with their contained bone proteins. They should not be ashed or subjected to a laborious and unnecessary preliminary rotting treatment in a compost heap. When bonemeal is to be applied to annual crops, the Kenya Department of Agriculture recommends that the fineness of grinding should be such that all the material passes through a 20-meshes-to-the-inch sieve and that at least 80 per cent of it passes through a 40-mesh sieve. If the material is to be applied to permanent crops such as grassland, coffee, tea or fruit trees, then a somewhat less fine material may be used.

Pot culture work with wheat seedlings carried out at the Scott Agricultural Laboratories in 1941 showed that the "early availability" of the phosphate nutrient of bonemeal was about proportional to its fineness and that material of the degree of fineness suggested above provided suitable amounts of readily available phosphate. Similar investigations showed that phosphate intake through the roots was greatest when bonemeal was placed in close proximity to the seed and not placed below the seed or broadcast throughout the soil. It was also shown that the best time of application was at seeding time and hence the recommendation that bonemeal should be applied in the form of a strip or ribbon application by means of the seed and fertilizer drill. Some of the results of laboratory investigations on the availability of bonemeal of wheat and the application of this knowledge to the phosphatic manuring of a range of Kenya arable soils appeared in the October, 1941, and January, 1943, issues of the *East African Agricultural Journal*.

For many years, over a thousand tons of bonemeal have been prepared per annum from waste bones collected mainly in the Game and Native Reserves of Kenya. The need for more bonemeal has led to a comprehensive scheme of bone collecting and milling in the Nyanza Province, and hundreds of tons of a suitably finely-ground, sterilized material have already been turned out at Kakamega by the agents of the Kenya Agricultural Production and Settlement Board. In cases where bonemeal is to be applied to certain scheduled crops, there is a Government subsidy that such bonemeal may be purchased at Sh. 140 per ton, which corresponds to the pre-war cost of this valuable fertilizer.

The Editor, The East African Agricultural Journal, Agricultural Research Station, Amani, Tanganyika Territory.

ERADICATING WEED TREES

Dear Sir,

I have had considerable success in eradicating weed trees on my cattle ranch, using a simple tree stabbing tool developed by the Forestry Department of Cornell University, New York, using a 5 per cent solution of sod. arsenite made up in bulk from four parts of white arsenic to one part of caustic soda. This is a simple tool that can be made anywhere, and because the poison enters into the cut at every stroke of the blade it is very much more effective than the standard axe-frill cut method of poisoning, much more rapid and economical of poison.

My other success in pasture maintenance after the weed trees have been removed has been with the Marden stalk and brush cutters, made by the Marden Company, of Auburndale, Florida. These are cylinders, 4 ft. in length, with longitudinal blades spaced 12 in. apart. My Case L. tractor takes three of these, giving a 12 ft. cut, but on level even ground would equally well take five, giving a 20 ft. cut. These are extremely simple machines that could be made anywhere and are amazingly effective. If of any interest I would send you photographs.

I have no personal motive in recommending you to try out these methods, but they have been my only success in cleaning and maintenance of my pasture lands, and you must have similar problems. I have had absolutely no success at all with oiling trees as recommended by Mr. Scott, of South Africa.

I do all my poisoning here on contract, and the natives will only use the Cornell stabbers; they don't get results with an axe.

Yours faithfully,

H. K. LONG.

Apartado 1410, Bogota,
Colombia, South America.
10th April, 1943.

[This letter is of interest not only for its content but also as showing the wide distribution of the *Journal*. As the subject is of such interest to East Africa we have asked the writer to let us have photographs and further particulars of his methods.—*Ed.*]

It is as impossible to check scientific discovery and its application to human purposes as to stop an inflowing tide. What those purposes shall be must depend on the degree of man's spiritual development, on the values in which he really believes.

Prof. A. G. Tansley in *Nature*.

A new world is being built up in Europe as in Africa, and it is no act of true benevolence to bestow on the latter notions which, let alone being incompatible with her own and disruptive in their effects, are obsolescent in the present stage of human evolution.

A. T. Culwick in *Good out of Africa*.

GRAFTING MALE PAPAW TREES*

By W. G. Hancock

This method of papaw grafting was evolved as a means of working over male papaw trees in the plantation, and with reasonable care, a really keen knife, and attention to details, it is quite easy to do. The results approach 100 per cent success, and a very strong union results.

Papaw tissue appears to be naturally very ready to unite, but the copious flow of sap, and the liability of the cut surface to rots, and the tendency of the stock to die back for a few inches are the main difficulties to be overcome. Moreover, scions, while keeping fresh and turgid under suitable conditions, will quickly wilt when exposed to dry air.

The stage preferred for grafting is when the stocks are between $1\frac{1}{2}$ inches and $2\frac{1}{2}$ inches in diameter; also the first flowers usually appear at this stage, and the sex can be determined.

The scions are side shoots from a mature tree; about 6 to 8 inches long is handiest, and the best are those which have a small hard knob at the base. If desired, a mature tree known to bear good fruit can be cut back some time before it is known that some grafting will be necessary. Indications are that in a comparatively short-lived plant like the papaw, shoots from a comparatively young tree are better than those from an aged tree. When grafted, the latter tends to produce a tree which appears senile from the beginning. Remove the leaves from the scions, leaving a short stub of the petiole. Rinse these in a strong solution of potassium permanganate and keep them wrapped in a cloth wrung out in it.

A very keen, thin-bladed grafting knife for the grafting cuts, and a stronger knife for preparing the stock, and some raffia, are required.

Drive a stake as near as possible to the tree without injuring it, and bind the top of the tree to the stake to prevent movement. Make a horizontal cut nearly three-quarters through the stock about 6 inches from the ground. The stems are solid at this point. Then commencing about 10 inches above this cut take out a deep slice from the stem. Swab all cut surfaces with potassium permanganate solution, but do not allow any on the actual grafting surfaces. This appears to hasten callousing, and stops the flow of sap. In the step so formed the cleft is made as near to the standing part as possible. The scion is cut wedge-shaped similar to an ordinary cleft graft, but as papaw tissue is very soft it is best to slightly shape the cleft and wedge to prevent undue pressure when the former is inserted. Bind with raffia, and mound up with moist sandy soil to just cover the tip of the scion. The portion of the trunk is left standing to maintain a flow of sap past the graft and prevent dieback.

In fourteen days the soil can be gently removed. By this time the raffia is rotted and the graft has either taken or failed. If the graft has taken, gently mound it up again. Growth should commence in about another two weeks, and when it has definitely started the standing part of the stock is cut off level, but the graft is kept covered with soil for a while to hasten a complete union and protect it from the heat of the sun.

The rapidity with which papaw tissue callouses under cover of moist earth is remarkable. In the case of the graft, whereas the surface of the lower sliced-away portion will have completely calloused in a fortnight, the top uncovered part will probably be already dry and shredding. Also, if a handful of moist soil is plastered over the cut top of a tree which for some reason or other has been cut down, it will very quickly heal over perfectly, instead of shredding and rotting back.

This graft has proved successful in North Queensland and also has been successful on occasions in southern districts of the State.

* Reprinted from *Queensland Agricultural Journal*, Vol. LIV, Part 5, pp. 377-379, 1940.

To my mind, the Soil Conservation Service has brought into being the most significant movement in agriculture in the Christian era.

Dr. W. C. Lowdermilk.

If we are to remove the fear of want as well as of war, science and statecraft must work together.

Mr. Anthony Eden.